Tintenbar to Ewingsdale

Upgrading the Pacific Highway

PREFERRED ROUTE REPORT
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NSW Roads & Traffic Authority

Pacific Highway Upgrade - Tintenbar to Ewingsdale

Preferred Route Report

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E1. Completing the Upgrade of the Pacific Highway

In January 1996 the NSW and Australian governments announced their joint commitment to a 10 year program to upgrade the Pacific Highway between Hexham and the Queensland border. As of September 2006, a total 233 kilometres are now double-lane divided road. A further 480 kilometres of highway are under construction, have been approved for construction or have had a preferred route identified. This will provide planning certainty for local communities and pave the way for a construction program to complete the upgrade of the Pacific Highway.

The Pacific Highway is an AusLink National Network road. For the 10 years to June 2006, $2.3 billion has been invested by the NSW and Australian governments. Over the past 10 years, the NSW Government has committed $1.66 billion and the Australian Government $660 million.

In December 2005, the NSW and Australian governments announced a jointly funded program of $960 million for the three years to 2009. In May 2006, the Federal Budget announced an additional $160 million, matched by NSW, for the period to the end of 2009. This increased the total value of the joint investment for the Pacific Highway Upgrade Program from $960 million to $1.3 billion.

Both governments are jointly examining how the entire length of the highway can be upgraded to dual carriageway in the next 10 years.

E2. Short and Long Term Planning for the NSW North Coast

The north coast is one of the fastest growing areas in NSW. The volume of traffic using the highway varies from area to area. The highway design may change to meet the needs of each area and to achieve an appropriate level of safety and accessibility.

A Motorway Style Roadway

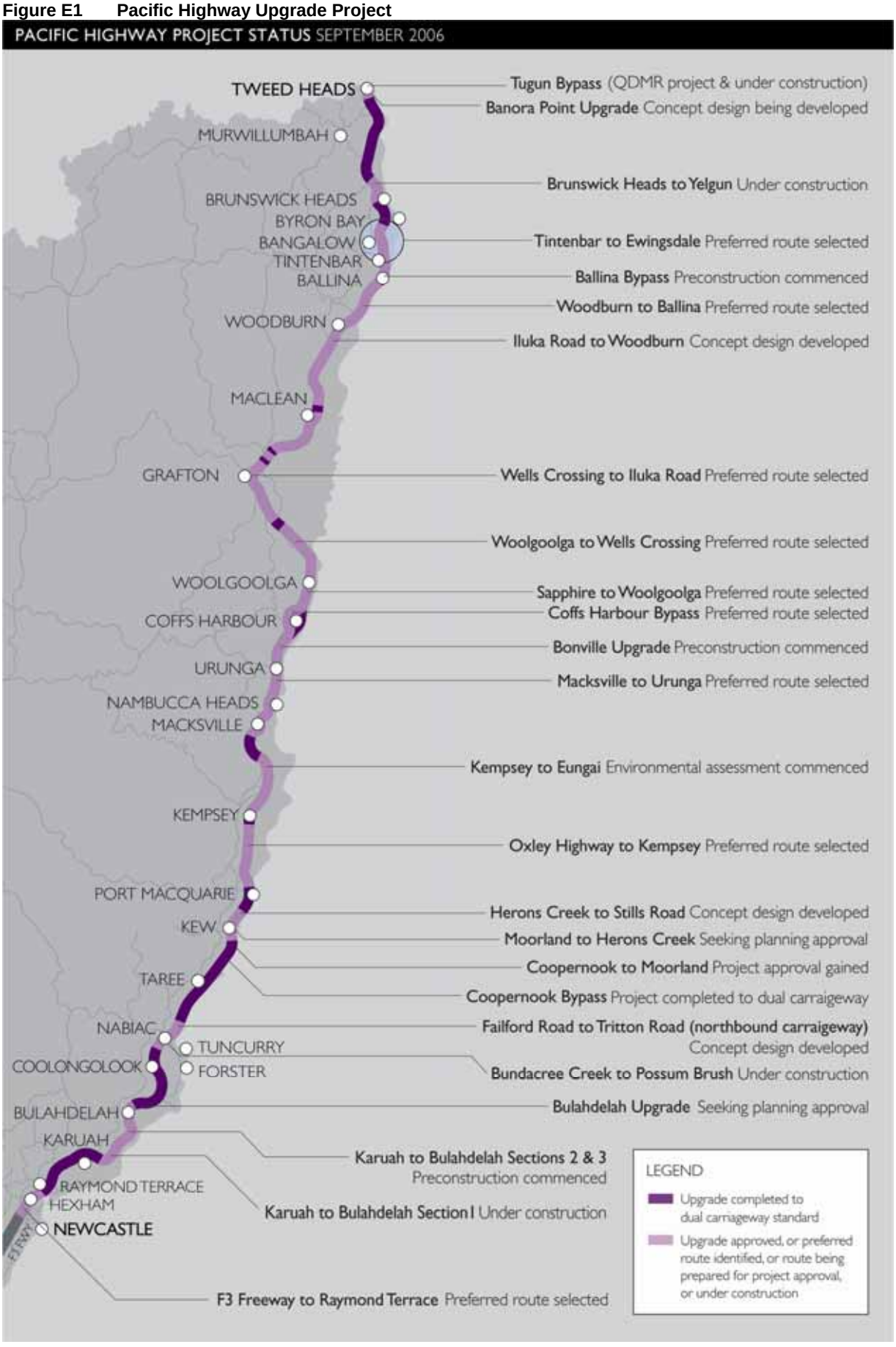
The NSW Roads and Traffic Authority (RTA) is planning for the long term in all cases. However in some areas the long term motorway standard is required now. This is because there are more people living nearby, requiring frequent and safe access to the highway. Providing a motorway style highway provides motorists with a choice:

- Of being able to use a local traffic route for slower speeds (80 km/h) and local access.
- Using the motorway for longer distance travel at higher speeds (110 km/h).

The Tintenbar to Ewingsdale project will have four lanes (two in each direction) in separate carriageways. The speed limit will be posted at 110 km/h. Access to the motorway will be controlled by:

- Interchanges with ramps to access the highway for frequently used areas.
- Local roads to cross above or below the highway.

Figure E1 Pacific Highway Upgrade Project



E3. Tintenbar to Ewingsdale Project

The RTA has engaged Arup to undertake route option investigations, environmental assessments, and concept development for the proposed upgrade of the Pacific Highway between Tintenbar and Ewingsdale. This upgrade is required to meet the NSW Government's objective of fully upgrading the Pacific Highway to dual carriageway from Hexham to the Queensland border.

The Tintenbar to Ewingsdale upgrade would link the proposed Ballina Bypass (from Sandy Flat Road) to the existing dual carriageway at Ewingsdale interchange, a distance of approximately 23 km. The boundaries of the project study area, shown in **Figure E2**, are:

- South to North: Sandy Flat Road, just south of Tintenbar, north to the Ewingsdale residential area.
- West: generally 0.5 km west of the existing Pacific Highway.
- East: Newrybar Swamp Road in the coastal flats, then up the coastal escarpment.

In October 2005, the *Route Options Development Report* (RTA 2005) was released and the short list of route options was placed on public display. This document, the *Preferred Route Report*, concludes the investigation process on the short list of route options with the selection of the preferred route.

Figure E2 Tintenbar to Ewingsdale Project Study Area

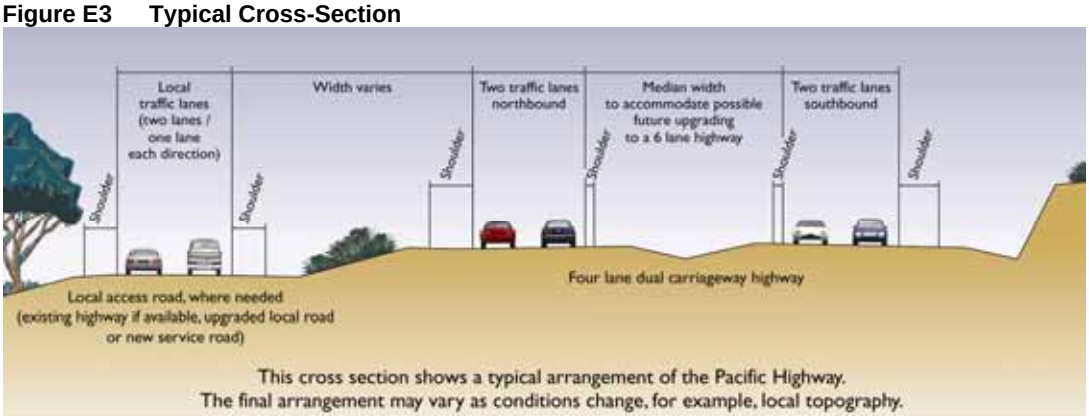
E4. Road Design and Upgrade Strategy

The Tintenbar to Ewingsdale upgrade will be designed as a 'M Class' upgrade as designated in the *Draft Pacific Highway Design Guidelines* (RTA 2005b). Key standards applying to this project are summarised in **Table E1** and a typical cross-section for the upgraded highway is shown in **Figure E3.**

Table E1 Road Design Standards

Feature	Upgraded Highway	Other Roads including Existing Pacific Highway
Design speed	110 km/h horizontal and 100 km/h vertical	100, 80 and 60 km/h dependent on function
Cross section	Dual carriageway with two 3.5 m wide lanes, inner shoulders 0.5 m, outer shoulders 2.5 m, minimum median width varies from 2.6 m to 12 m depending on median barrier type	Two lane single carriageway with maximum 2 m shoulders dependent on road function
Vertical grades	Desirable maximum grade 4.5% Absolute maximum grade 6% (desirable maximum length 500 m) Climbing lanes may be required depending on length of sustained grades above 4.5%	Not specified, refer Road Design Guide (RTA 1996)
Flood immunity	1 in 100 year desirable or 1 in 20 year absolute minimum across floodplain. Effects of Probable Maximum Flood to be assessed	No change to existing conditions
Intersections	Grade separated, no at-grade intersections permitted	At-grade
Access to highway	Restricted	Unrestricted
Local access	Alternative routes to be provided	Service roads or local arterial road networks to provide alternative routes for local traffic
Clearances above highway	5.3 m for the full road width including shoulders (5.3 m for any pedestrian bridges), 7.5 m above railway	5.3 m desirable, 4.6 m minimum

Figure E3 Typical Cross-Section



E5. Community and Stakeholder Involvement

A comprehensive community and stakeholder involvement program has been established for this project. Community involvement is undertaken during key stages of the project to ensure that relevant stakeholder views and information are incorporated into the decision making processes. In particular, community involvement has been sought during the project familiarisation phase and the route options development and assessment phase. To date, the following methods have been used to engage the community and stakeholders:

- Community Information Sessions.
- Establishment of a website, project information (freecall) line, email, and freepost.
- Community Updates, and progress updates in local media.
- Project Team attendance at community meetings.
- Establishment of a Community Liaison Group, Agricultural Focus Group and Aboriginal Focus Group.
- Individual property owner meetings and direct contact.
- Corridor Assessment Workshop.
- Public display of route options and the *Route Options Development Report* and receipt of submissions.
- Value Management Workshop.

The community has provided a wealth of local knowledge that has been reviewed and considered by the Project Team. Community submissions have been received by letter, feedback forms, email, fax and the project information line, as well as through individual property visits and meetings. These submissions were collected and analysed to achieve an understanding of the key issues.

Information and input was also sought from government agency representatives, regional and local organisations and other stakeholders at project commencement and other key stages of the project, including the public display of the route options and the *Route Options Development Report*.

Relevant government agencies/organisations were invited to attend the Planning Focus Meetings in November 2004 and February 2005, the Corridor Assessment Workshop in August 2005 and the Value Management Workshop in December 2005.

The extensive community involvement program has resulted in the community and agencies being widely and regularly consulted. Issues raised by the community and agencies have been addressed through meetings, by email or telephone, or in the *Route Options Submissions Report* (RTA 2006).

E6. Short List of Route Options

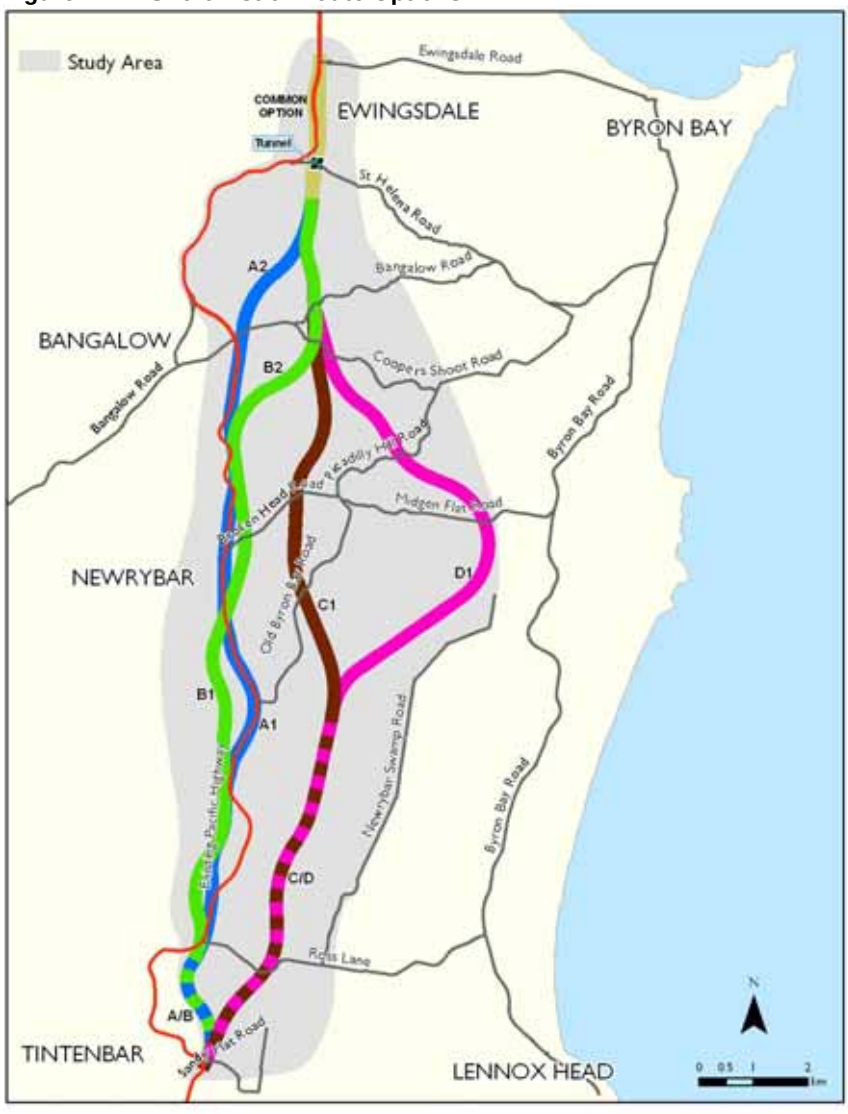
Route options for the Pacific Highway upgrade were developed through an iterative process involving a range of environmental, engineering, urban design, community, safety and cost considerations structured around the following route options stages.

Preliminary Investigation → **Initial Options** → **Long List of Options** → **Short List of Options** → **Preferred Route**

The process that led to the selection of the short list of route options is detailed in the *Route Options Development Report*. The shortlisted options, shown in **Figure E4**, are designated as Option A, Option B, Option C, Option D, and the Common (tunnel) Option that includes tunnel approach options T1 and T2. Key alignment differences in the options are:

- Option A incorporates an upgrade generally following the existing highway corridor.
- Option B is a plateau option in an entirely new corridor.
- Option C traverses the escarpment.
- Option D is partly located on the eastern coastal plain.

Figure E4 Short List of Route Options



E7. Outcomes of the Public Display

The public display of the route options and the *Route Options Development Report* was held from 21 October 2005 to 2 December 2005. A range of consultation tools was used to facilitate and encourage community and stakeholder feedback on the route options including advertisements, information brochures, landowner meetings, a community information centre, and public displays.

The depth and effectiveness of the consultation process is demonstrated by attendance at the public displays and community information centre, the large number of submissions received on the project, and the numerous meetings held with landowners and the Project Team.

Over 19,000 submissions were received in the six weeks following the release of the *Route Options Development Report* (see **Chapter 4**). Frequently raised issues include:

- An inland route particularly for freight is a better option.
- Alternative routes (and modes) should be considered.
- Upgrade on or near the existing highway is preferred.
- Impact on waterways in terms of drinking water quality and aquatic ecology.
- Ecological impacts on the escarpment and coastal plain.
- Visual impacts on the scenic escarpment and coastal plain.
- Agricultural impacts.
- Use of Ballina Bypass, Bangalow Bypass, and 9(a) proposed road reserve zone.
- Impacts on communities and livelihoods.
- Noise and vibration impacts.
- Road safety.

As a result of feedback from the community and agencies, further engineering and environmental investigations were undertaken. Additionally, relevant data obtained through the submissions were incorporated into the updated constraints analysis.

E8. Value Management Process

As part of the planning for the Tintenbar to Ewingsdale project, a value management process has been established to review highway planning investigations and identify the values which are collectively important within the study area. As part of this process, a Corridor Assessment Workshop was held in August 2005 to bring together a wide range of stakeholder interests and expertise. The Corridor Assessment Workshop was followed by a Value Management Workshop held in December 2005 after the public display of the shortlisted route options.

The Value Management Workshop group reviewed and evaluated the short list of route options, and provided recommendations for further investigations and route option refinement. The conclusions and recommendations agreed by the Value Management Workshop group are listed below.

- All corridor options have impacts in the study area (there is no perfect option).
- Option B2 and Option C1 should not be considered further.
- Option A1, Option A2, Option B1, and Option D were preferred over other options, subject to further investigations.
- Further investigations were recommended regarding:
    - The agricultural economic impacts of Option D (including agricultural land values and relative impacts).
    - The noise impacts of tunnel options T1 and T2.

  - Examination of frequent rainfall events that relate to farming irrigation practices and water management in the zone between the surface and 'ground water' levels.
  - Air quality and emissions from potential highway corridors; and establish a view on the potential impact on public health.

- There is opportunity to look at combinations of A1 and B1 to find the most suitable alignment in terms of the assessment values recorded.
- Further investigation of economic impacts for both the regional and local perspective was recommended.

E9. Updated Work Since the Route Options Development Report

Since completion of the *Route Options Development Report* and the Value Management Process, the Project Team has continued with investigations and the route development process that leads to the selection of the preferred route. Additional work that has been conducted since the *Route Options Development Report* includes:

- Updated constraints mapping (based on additional field investigations and studies).
- Detailed agricultural studies and resulting economic impacts of the options.
- Local and regional economic analysis.
- Design modifications made to the short list of route options.
- Predicted traffic flows for the key local roads.
- Local access arrangements for the shortlisted route options.
- Flood analysis including detailed hydraulic modelling in the Newrybar Swamp area.
- Development of the concept designs, resulting in the refined design corridors for the short list of options (including structure and drainage requirements).
- Assessment of subsections of A1 and B1 based on locations where these two sections cross. The subsections are designated as A1-a, A1-b, A1-c, B1-a, B1-b and B1-c.

As a result of additional studies undertaken since the *Route Options Development Report* and the Value Management Process, there have been some minor modifications to the short list of route options, as follows:

- The alignment of Section A1 at Knockrow was shifted closer to the existing highway to reduce agricultural impacts and to reduce the impact on a spring fed dam.
- The alignment of Section B1 between Knockrow and Newrybar was shifted further away from Emigrant Creek and closer to the existing highway to reduce construction risks to Emigrant Creek.
- The alignment of Section C/D was shifted west at Martins Lane to reduce environmental, geological and social impacts.
- Section D1 was shifted slightly to the east so that the alignment further north could avoid a high value environmental constraint.

E10. Technical Assessment of Short List of Route Options

The technical assessment is based on the short list of options (as modified) and their performance based on designated criteria. This step of the route options development process includes the following:

- Review of the short list of route options, including the subsections.
- Review and update of evaluation criteria used for the technical analysis.
- A pairwise process undertaken for weighting of the technical evaluation criteria and sensitivity analysis.

- Evaluation of performance of the short list of route options against the technical evaluation criteria.
- Reduction of the short list to the top performing options.
- Comparison of the top performing options.
- Identification of the best performing route option as the outcome of the technical analysis.

The results of the technical comparisons are as follows:

- Options A and B perform better than Options C and D.
- Combinations of subsections for A1 and B1 perform better than A1 and B1 as stand alone sections.
- A1-a performs marginally better overall compared to B1-a and is preferred.
- B1-b performs better overall compared to A1-b and is preferred.
- Section A2 is preferred over B2 as it utilises both the 9(a) proposed road reserve zone and almost half of the existing Bangalow Bypass.
- T2 performs marginally better overall compared to T1 and is preferred.

In summary, the preferred route option resulting from the technical assessment includes: A/B, A1-a, B1-b, B1-c, A2 and T2.

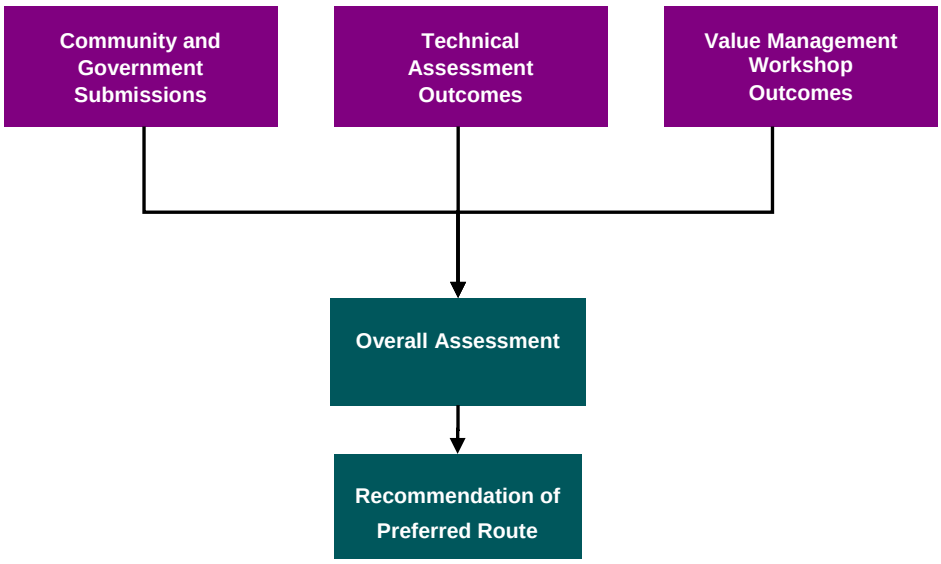
E11. Recommendation of the Preferred Route

The recommendation of the preferred route is an outcome based on the results of three independent 'streams' of work conducted on the Tintenbar to Ewingsdale Pacific Highway Upgrade. These three streams are:

- Community and agency submissions on the Route Options Display held in late 2005 and the corresponding *Route Options Development Report* as reported in the *Route Options Submissions Report.*
- The Value Management Workshop for the short list of route options held in December 2005 and reported in the *Value Management Workshop Report* (RTA 2006).
- The technical assessment of the short list of route options as reported in this document.

After comparing the outcomes of the three streams, the Project Team then considered costs and value for money in an overall assessment. This process is outlined in **Figure E5**.

Figure E5 Process for Recommending Preferred Route



Comparison of the outcomes from the three streams provides the following results as shown in **Table E2:**

- Options A and B are preferred over Option C in all streams.
- Options A and B are preferred over Option D in two streams.
- A2 was preferred in one stream, and B2 was a poor performing option in one stream.
- T2 was preferred in two streams, and considered similar to T1 in one stream.

Table E2 Outcomes of the Three Streams

Options	Community and Agency Submissions*	Value Management Workshop	Technical Assessment
Options A, B, C and D	A and B preferred over C and D	C was the worst performing option and there was uncertainty regarding Option D	A and B preferred over C and D
A2 and B2	No definitive results	B2 performs poorly and should not be considered further	A2 preferred over B2
T1 and T2	T2 was preferred over T1	T1 and T2 considered similar	T2 preferred over T1

*Based on submissions received on the Route Options Display and the Route Options Development Report.

The overall assessment considered the outcomes of the three streams, cost comparisons, and value for money considerations and concluded:

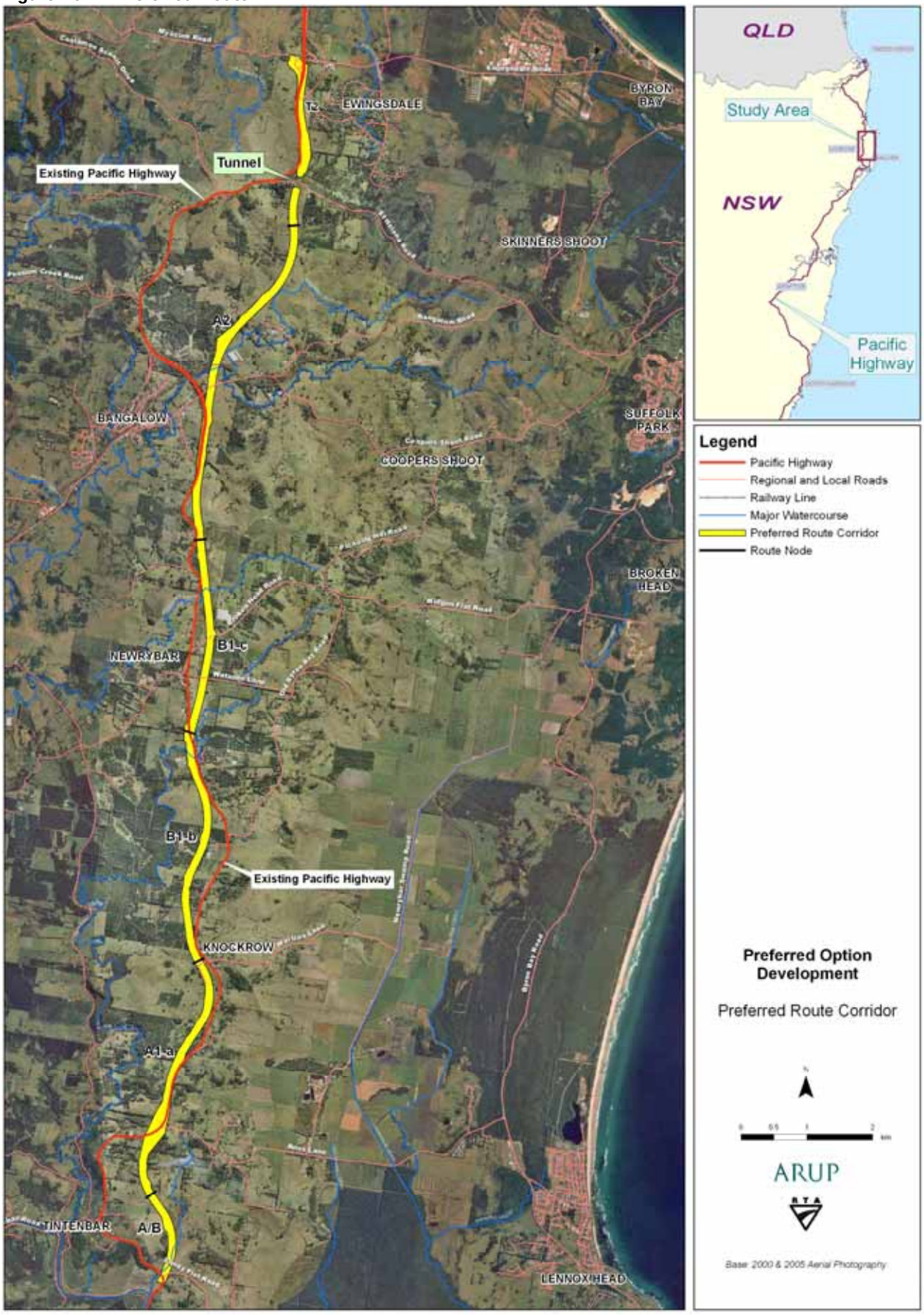
- Options A and B perform better than Options C and D.
- A1-a is preferred over B1-a.
- B1-b is preferred over A1-b.
- A2 is preferred over B2.
- T2 is preferred over T1.

Based on the comparison of the outcomes of the three streams, costs, and value for money considerations, the recommended preferred route (see **Figure E6**) is the option made up of: **A/B, A1-a, B1-b, B1-c, A2** and **T2**. This route was selected for the following key reasons:

- Provides the best overall balance between functional, ecological, heritage, social, and economic considerations and provides staging opportunities.
- Best meets the objectives of both the Pacific Highway Upgrade Program and the Tintenbar to Ewingsdale project.
- Achieves high safety standards.
- Provides for grade separation of the upgraded Pacific Highway and the local road system.
- Provides reasonable physical separation from existing and proposed major residential areas such that acceptable visual and traffic noise outcomes could be achieved with sensitive urban design.
- Considers the outcomes of the Value Management Workshop and community submissions.
- Allows for potential water quality risk reductions in the Emigrant Creek Dam area.
- Provides good road user benefits for a reasonable construction cost.
- Retains Macadamia Castle, a local landmark.
- Retains the existing highway as a local/tourist road.

- Has a lower impact on the escarpment and visual amenity compared to coastal options.
- Provides a good outcome in terms of transport efficiency.
- Utilises the highest amount of existing and planned highway reserves (Ballina Bypass, 9(a) proposed road reserve zone and Bangalow Bypass).
- Avoids known Aboriginal heritage sites.
- Avoids State significant agricultural land.
- Has a lower impact on Endangered Ecological Communities compared to coastal options.
- Has a lower risk associated with soft soils, flooding and land slips compared to coastal options.
- Has the minimum impact on wildlife corridors compared to other options.
- The T2 tunnel has reduced travel time, lower greenhouse gas emissions, less road user costs and is safer than the T1 tunnel.
- Impacts on agricultural properties could be reduced, where possible, through discussions with individual land owners and refinement of the design.

Figure E6 Preferred Route



E12. The Preferred Route

The preferred route is described below by section and shown from south to north **Figure E7** through to **Figure E11**. These figures show the nominal 120 m wide preferred route corridor.

Section A/B

The preferred route utilises the approved Ballina Bypass corridor with some minor amendments to the geometry so that it meets the current design standards.

Section A1-a

This section includes the northbound climb up the southern escarpment with a grade of 5.9% over about 1.5 km. It contains the Ross Lane interchange which is similar in layout to that proposed as part of the Ballina Bypass.

The alignment then follows a corridor just to the west of the existing highway. The alignment avoids the residential clusters near Knockrow and also passes just to the west of the Rous Water reservoir on the hill opposite Knockrow. It keeps as close to the existing highway as possible, while complying with the design standards and avoiding the Rous Water facility. Following the existing highway as closely as possible also reduces the impact on agricultural properties which generally extend from the existing highway all the way back to Emigrant Creek and the dam.

Section B1-b

From Martins Lane the preferred route diverges to the west, avoiding any direct impact on Macadamia Castle and achieving a higher standard of geometric alignment than would be possible following the existing highway corridor.

North of Macadamia Castle, the preferred route runs parallel to and west of the existing highway for about 600 m and then merges back to a corridor located just west of the existing highway. South of Hambly Lane, the preferred route crosses an unnamed creek on twin bridge structures approximately 90 m long and crosses Emigrant Creek on twin bridges structures approximately 120 m long.

Section B1-c

Just north of the Emigrant Creek crossing, the preferred route crosses to the east side of the existing highway. The preferred route passes underneath the existing highway and the existing highway would be reconstructed on a bridge, approximately 150 m long, above the preferred route. The preferred route passes over Watsons Lane about 300 m east of Newrybar. An underpass would be provided to allow access for local traffic.

The alignment diverges to the east of both Newrybar and the Newrybar Primary School so that these two entities are not separated. On the north-east side of the school, the alignment passes underneath Broken Head Road in a cutting about 12 m deep. Broken Head Road would pass above the preferred route on a bridge about 130 m long, providing continued access to Newrybar, the school and the existing highway. There would be no direct connections between Broken Head Road and the preferred route.

North of Broken Head Road, the alignment moves back towards the existing highway, crossing Skinners Creek on twin bridge structures about 120 m long before merging onto the section 9(a) proposed road reserve zone that is designated for highway usage (see **Figure 1.5** for location of 9(a) zoning).

Section A2

The preferred route follows the 9(a) proposed road reserve zone to the east of the existing highway, avoiding the tight curves and steep grades of the existing highway before connecting onto the southern end of the Bangalow Bypass. The northbound carriageway of the Bangalow Bypass would be converted to a two-way local road while the southbound carriageway would become the northbound carriageway of the preferred route. A new southbound carriageway for the preferred route would be constructed on the east side of the existing Bangalow Bypass.

Just south of Bangalow Road, the preferred route diverges to the east, away from the Bangalow Bypass. Twin bridge structures, about 30 m long, would be provided above Bangalow Road and longer twin bridge structures, about 175 m long, would be provided above Byron Creek and the railway line on the north bank of the creek. The alignment then follows Tinderbox Valley, remaining on the west side of Tinderbox Creek.

An underpass would be provided to maintain local access to Tinderbox Road, but no frontage roads would be required through this section which ends about 500 m south of the tunnel portal.

Section T2

The preferred route goes through a tunnel structure approximately 250 m long and about 45 m below St Helena Road. A separate tunnel would be provided for each carriageway.

On the north side of the tunnel, the preferred route is aligned just to the east of the existing highway such that the existing highway can be retained as a local road. The alignment runs as close as possible to the existing highway before merging onto the existing highway just south of the existing Ewingsdale interchange. The grade is 4.4% over a length of about 1.5 km. Where the preferred route passes the Ewingsdale residential area, it is lower and slightly closer to Ewingsdale than the existing highway.

E13. Project Cost Estimates

Strategic cost estimates have been prepared for the preferred route. The estimates are based on preliminary designs as well as preliminary geotechnical investigations.

The total cost of the project is estimated at $368 million at March 2006 costs.

E14. Next Steps

The next steps for the development of the Tintenbar to Ewingsdale Project include:

- Public exhibition of the preferred route.
- Refinement of the preferred route corridor including the alignment of Sections A1-a, B1-b, and T2.
- Submit a proposal to the NSW Department of Planning for approval under Part 3A of the Environmental Planning and Assessment (EP&A) Act 1979. The proposal would be the subject of an environmental assessment which would examine the potential impacts of the preferred route. The environmental assessment would include a statement of commitments in respect of environmental management and mitigation measures proposed to be undertaken if the project is approved.
- When completed, the environmental assessment would be publicly exhibited and submissions sought. The RTA may be asked to prepare a report on the submissions, consider modifications to the project to minimise environmental impacts, and revise its statement of commitments.
- The NSW Department of Planning would consider the environmental assessment, the public submissions and any additional reports in recommending to the Minister for Planning whether the project should be approved.

Figure E7 Preferred Route Sections A/B and A1-a

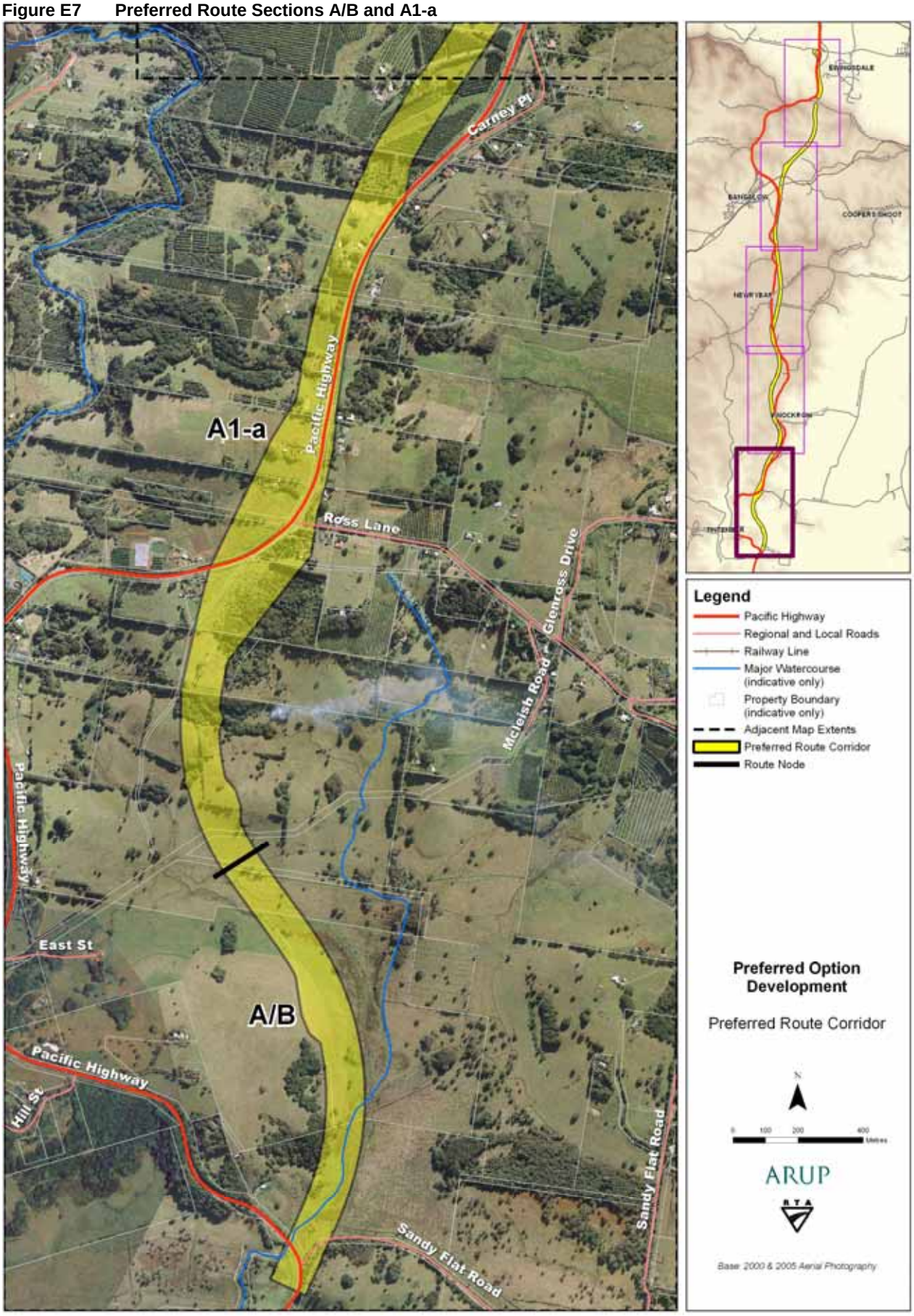


Figure E8 Preferred Route Sections A1-a and B1-b

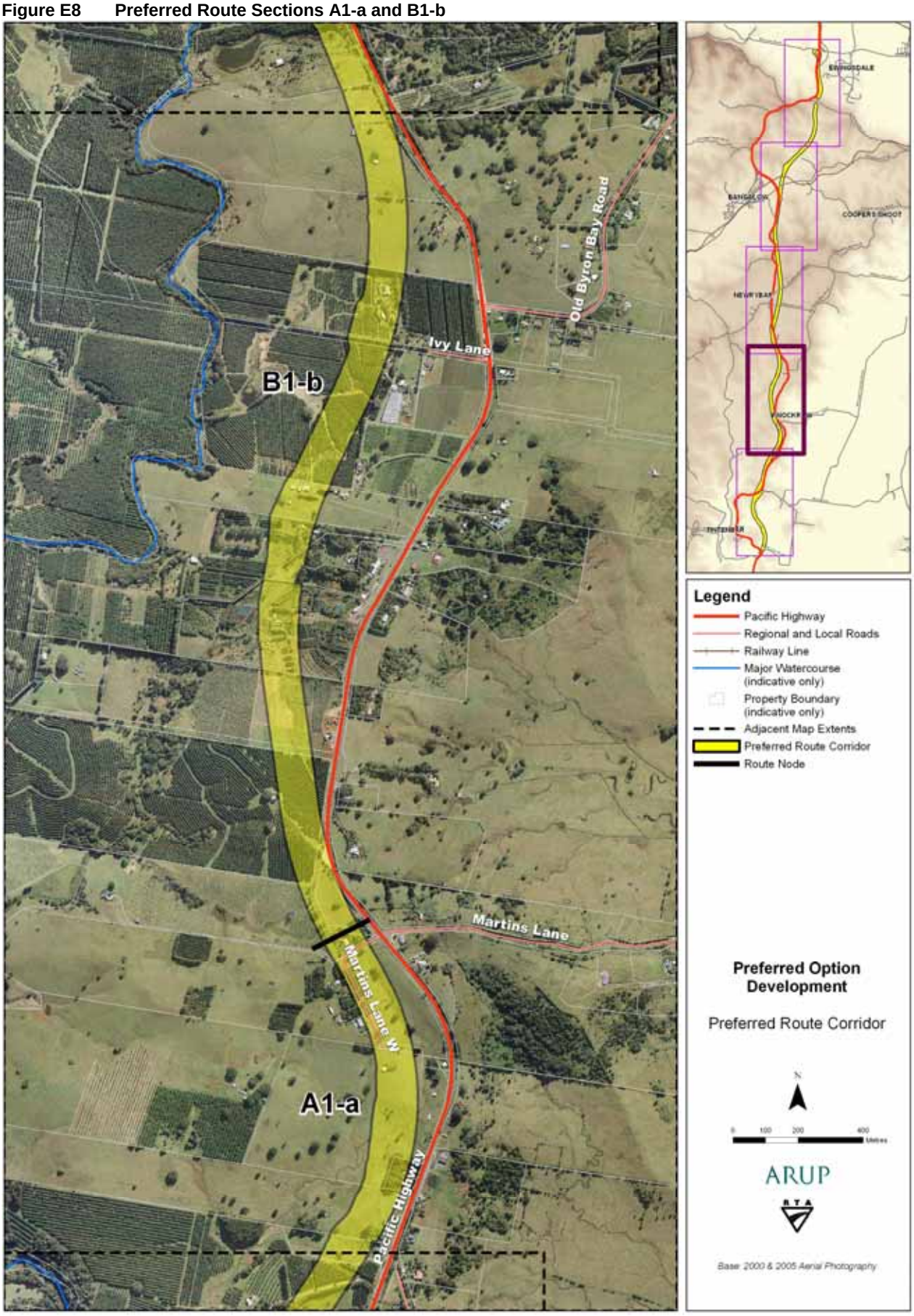


Figure E9 Preferred Route Sections B1-b and B1-c

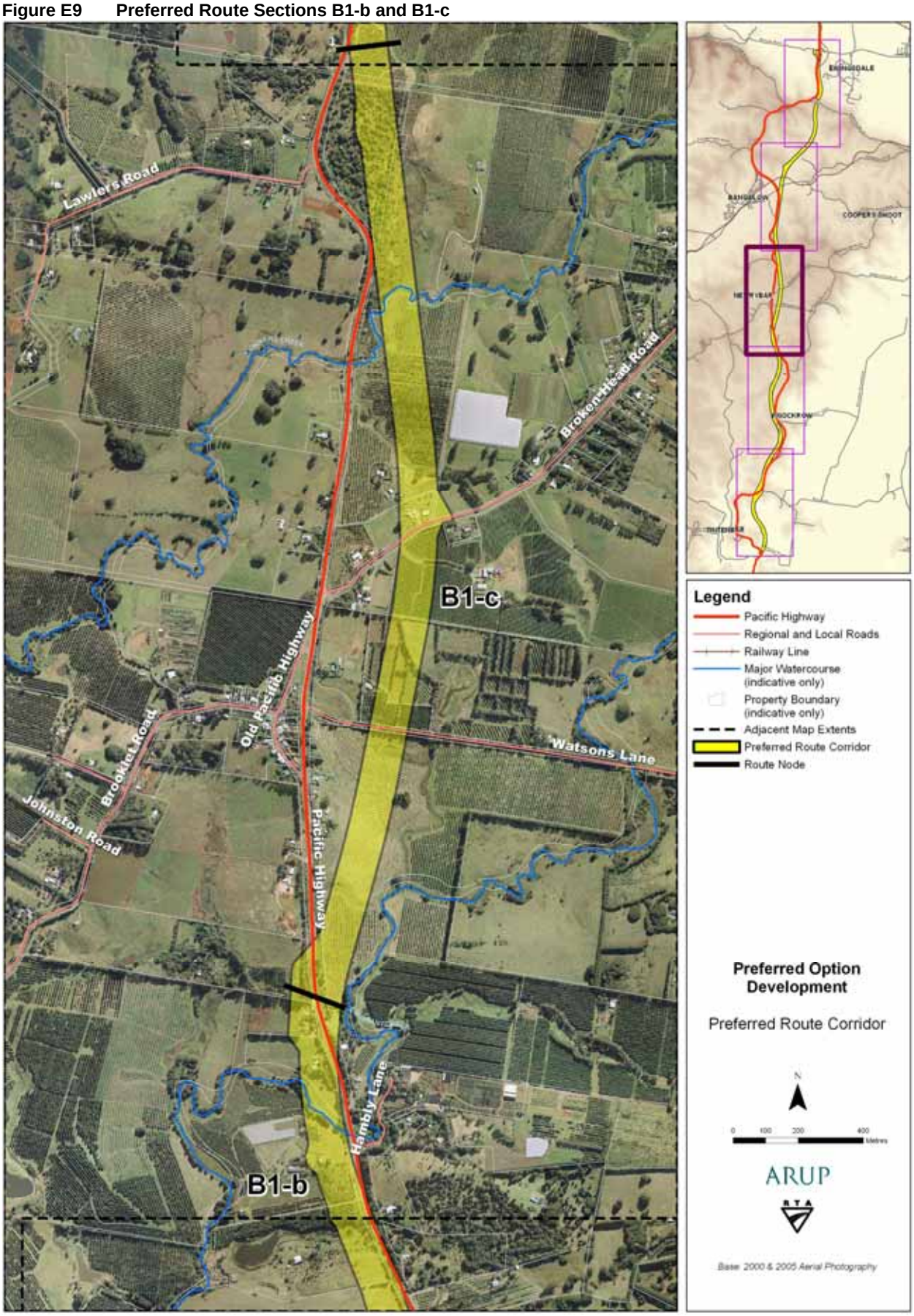


Figure E10 Preferred Route Sections A2

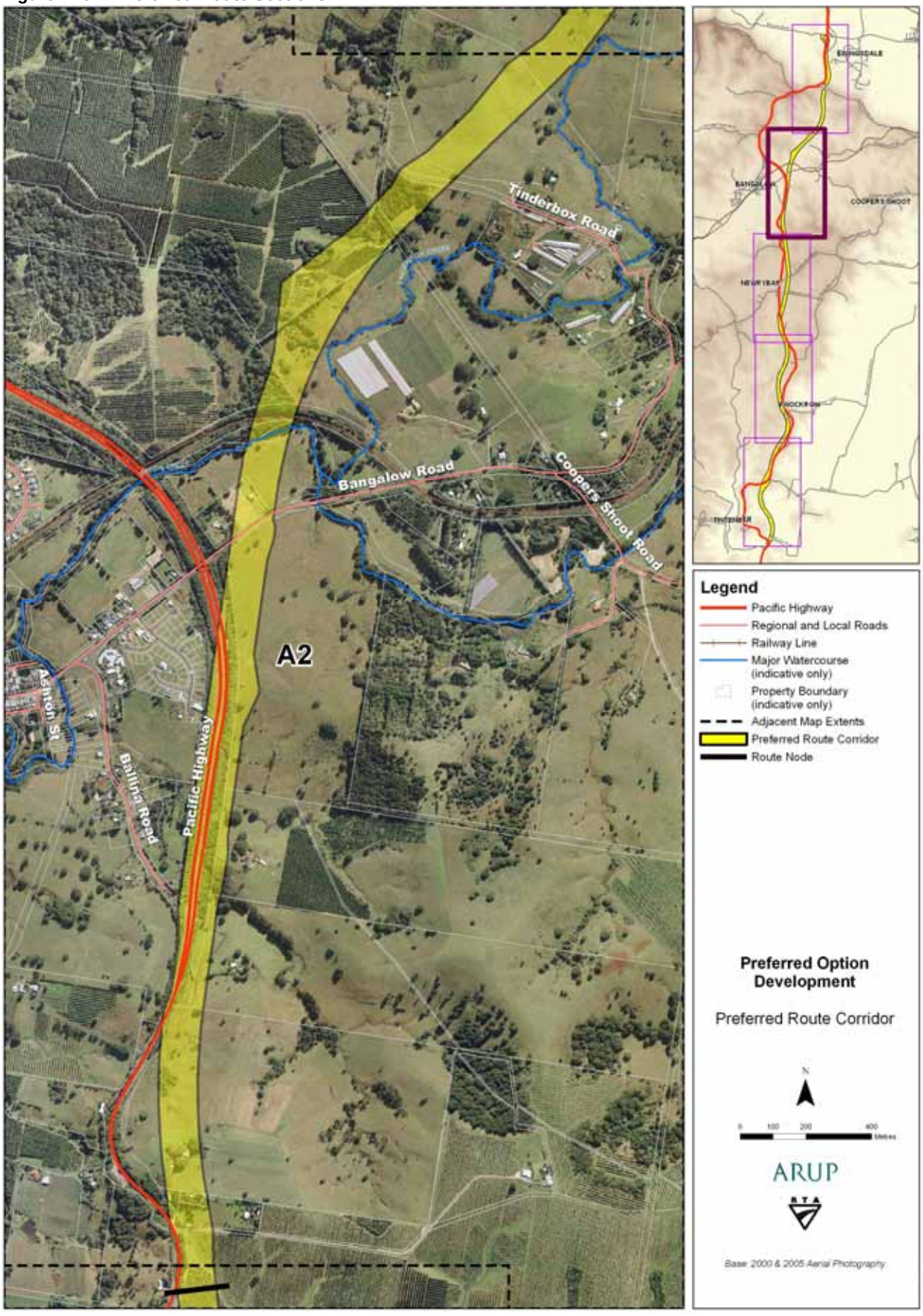
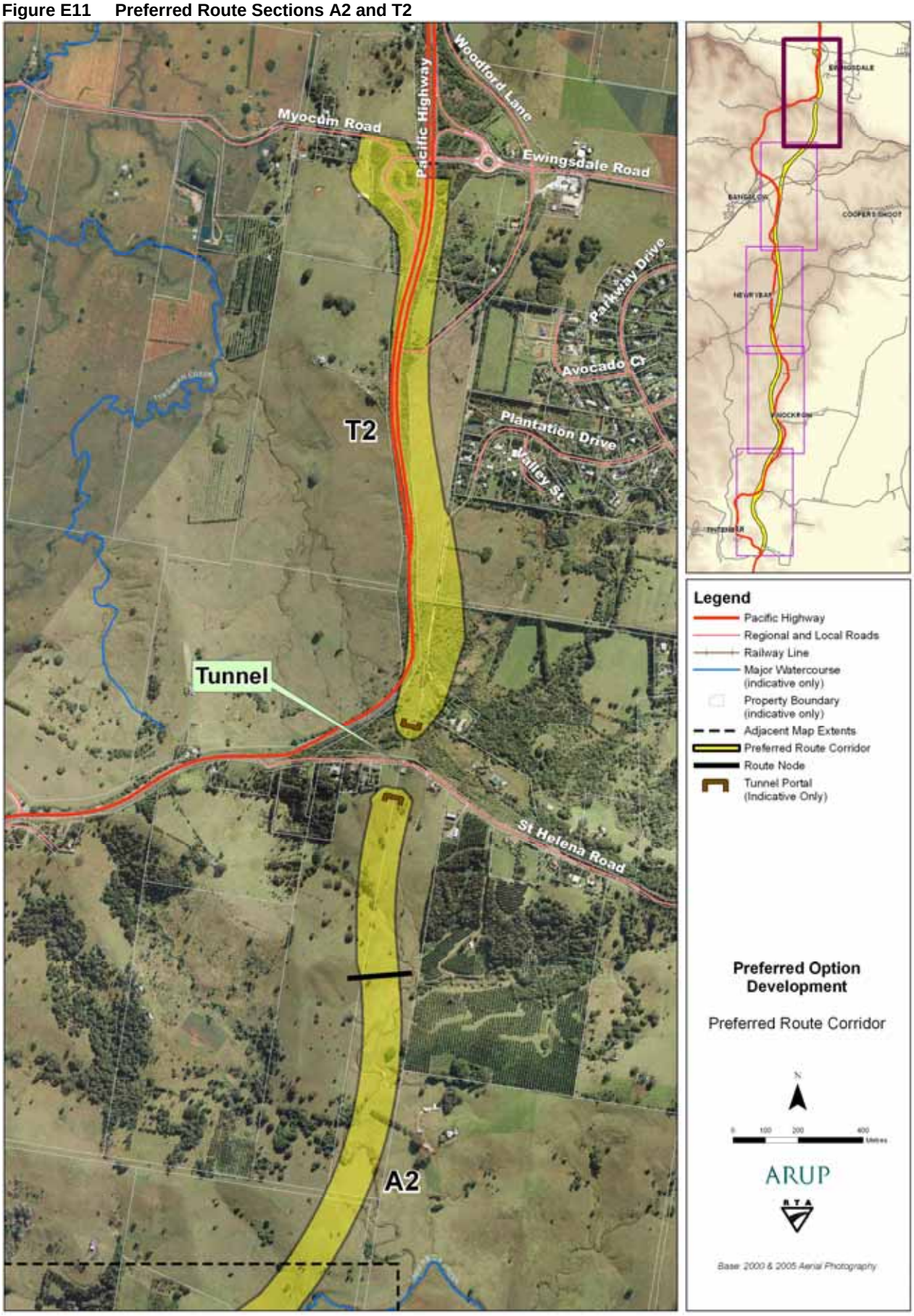


Figure E11 Preferred Route Sections A2 and T2



1 Introduction

1.1 Background

The NSW Roads and Traffic Authority (RTA) has engaged Arup to undertake route option investigations, environmental assessments, and concept development for the proposed upgrade of the Pacific Highway between Tintenbar and Ewingsdale. This upgrade is part of the overall Pacific Highway Upgrading Program and will link the northern end of the approved Ballina Bypass to the existing dual carriageway at Ewingsdale.

In October 2005, the *Route Options Development Report* (RODR) (RTA 2005) was released and the short list of route options was placed on public display. This document, the *Preferred Route Report* (PRR), concludes the investigations on the short list of route options with the selection of the preferred route.

The Tintenbar to Ewingsdale Upgrade project is required to meet the NSW Government's overall objective of fully upgrading the Pacific Highway to dual carriageway from Hexham to the Queensland border. **Figure 1.1** identifies the various Pacific Highway Upgrading Program projects and their status.

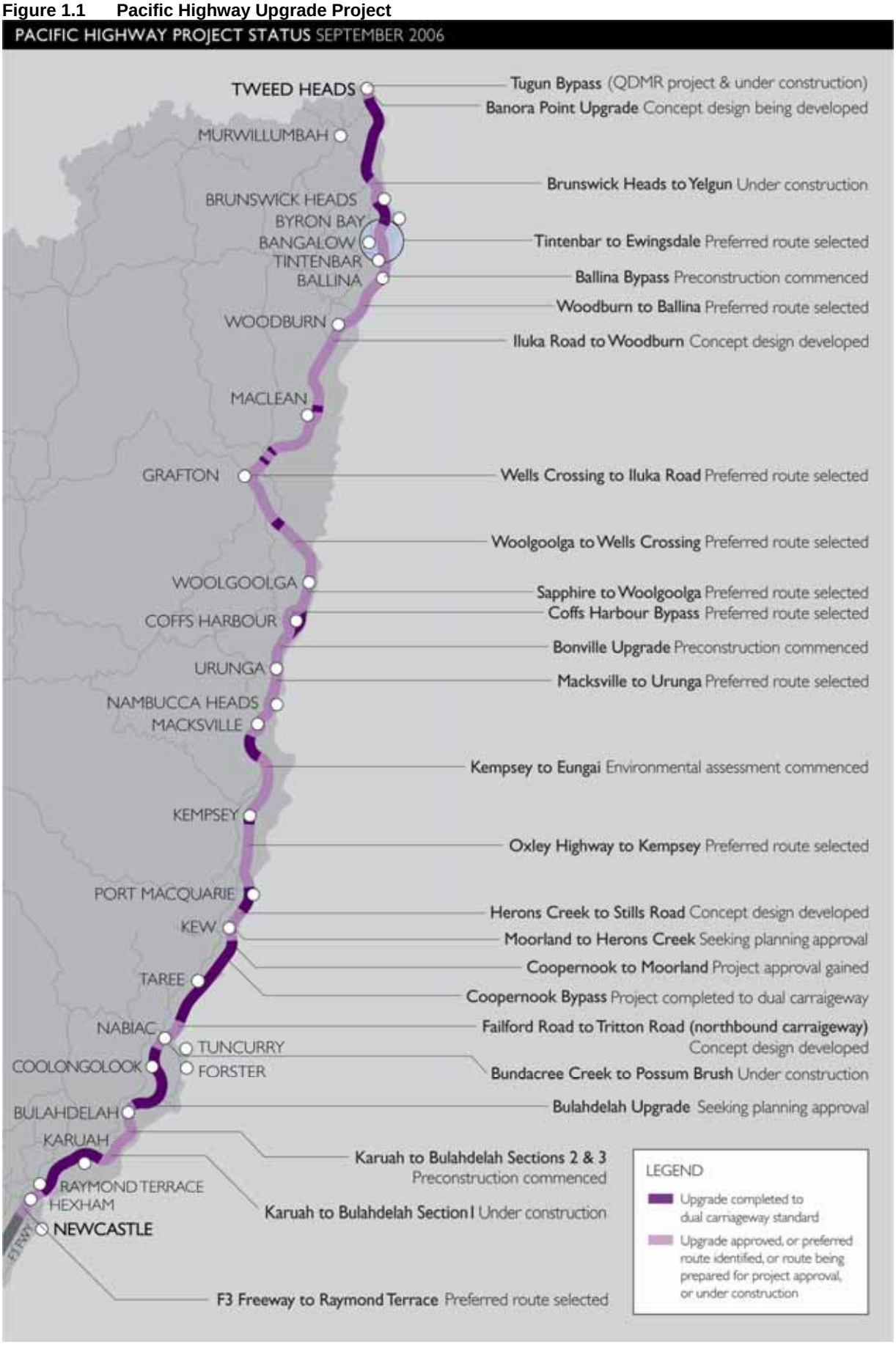
1.2 Need for the Project

The Pacific Highway is a vitally important part of the State and National infrastructure and as such needs to be maintained to a level which is adequate for its intended purpose. It is the major North-South transit route between NSW and Queensland and also acts as a local access thoroughfare for private and commercial traffic in the area. The need to upgrade the Pacific Highway between Tintenbar and Ewingsdale is based on a combination of factors including local and regional growth, economic considerations, and road safety issues. Based on predicted increases in traffic levels along this route, the current configuration of the Pacific Highway would struggle to safely and efficiently meet future needs. An upgrade of the highway is required to address the existing traffic and safety issues and the forecasted transport needs.

1.2.1 Local and Regional Growth

Recent and forecasted growth in the Ballina and Byron local government areas (LGAs), and within the entire north coast region, indicate an increasing pressure on the existing transport system. In the Tintenbar to Ewingsdale context, the highway is significant in its facilitation of transport movements associated with local business and agriculture as well as providing a road network to support the local tourism industry. Highway upgrade considerations address local as well as regional issues, and care has been taken in order to maximise local access while limiting any potentially negative growth effects such as possible segregation of communities or the limiting of urban boundaries. Conversely, the positive growth benefits associated with the improved highway are expected to be considerable as it will provide safe, efficient access for social activity, trade, tourism, and emergency services.

Figure 1.1 Pacific Highway Upgrade Project



1.2.2 Road Safety Issues

The need for the upgrade is strongly supported in road safety terms, both at the local and regional level. There are higher than acceptable crash rates and serious accident levels along the Tintenbar to Ewingsdale highway section. This situation is ongoing and difficult to resolve without an improved road. Local residents also experience safety problems when accessing the current highway, such as pedestrians and cyclists attempting to cross the highway in the Newrybar area and at other smaller settlements.

In regional terms, it is desirable that motorists have a uniform standard of safe roads. Continuity of high quality road conditions directly correlates with lower levels of accidents, especially fatalities. Additionally, the predictability of an improved highway with uniform road conditions will reduce driver fatigue and frustration, both of which are contributing factors to accidents.

The Pacific Highway both north and south of the Tintenbar to Ewingsdale project is already dual carriageway or 'approved' planned dual carriageway. In this context the Tintenbar to Ewingsdale upgrade should be considered as part of the overall highway upgrade strategy; thereby reducing safety concerns associated with an unimproved section.

If the current proposal was dropped and no highway upgrade was undertaken, a considerable increase in the accident rate and associated safety problems could occur. Specific road safety implications would include likely increases in the:

- Number and severity of accidents, especially where road conditions are currently sub-standard.
- Number and severity of accidents at the numerous at-grade intersections, especially where the layout or sight distance is currently sub-standard.
- Level of risk for pedestrians when crossing the highway, particularly in Knockrow and Newrybar.
- Difficulty for residents adjacent to the highway to gain access to and from the highway.
- Level of risk for cyclists using the highway.

For all indicators of road safety there is a clearly demonstrated need to provide a higher standard of road for this section of the Pacific Highway.

1.2.3 Government Transport Policies

The Pacific Highway corridor connects Sydney, Newcastle and Brisbane with a number of regional centres, major towns and villages. The regional context of the project is shown in **Figure 1.2**.

The need for the highway upgrade should be considered in relation to broader transport and road network planning carried out by the State and Commonwealth Governments. This strategic planning has resulted in publication of a number of planning studies and the establishment of Commonwealth and NSW Government strategies and initiatives which relate to that section of the Pacific Highway within NSW. The Pacific Highway is generally the principal financial responsibility of the NSW Government in NSW and the Queensland Government in Queensland; however there are some Commonwealth and NSW Government initiatives involving joint funding between the State and Commonwealth Governments on some transport projects, including the Pacific Highway Upgrading Program and AusLink: Building our National Transport Future.

These initiatives provide the strategic planning context for the upgrading of the Pacific Highway between Tintenbar and Ewingsdale and summarised below:

Figure 1.2 Regional Context of Project

- The Pacific Highway Upgrading Program (RTA 1997) provides a ten year commitment to develop the existing highway between Hexham and the Queensland border. The initial funding commitment in NSW was $2.2 billion over ten years. The objective was to significantly improve the standard of the Pacific Highway and provide a safer and more efficient transport link, with the result that accident 'blackspots' be eliminated and travel times reduced. The agreed Program ends in June 2006, however the State and Australian Governments have both committed to extending the program.
- AusLink is the Australian Government's policy (Australian Department of Transport and Regional Services 2004) for improved planning and accelerated development of Australia's land transport infrastructure. It addresses the planning and funding of Australia's national roads, railways and intermodal terminals by taking a long term, strategic approach to future needs.
  The objectives of the plan are to provide transport benefits for businesses, local communities, exporters and farmers. In addition, there would be environmental benefits from reduced congestion, pollution and more efficient transport. The AusLink National Network is based on national, regional and urban transport corridors, links to ports, airports, and intermodal connections between road and rail. The AusLink National Network incorporates the former National Highway system and many Roads of National Importance, including the Pacific Highway between Newcastle and Brisbane.

In addition, there have been a number of other recent studies and documents addressing the upgrading of the Pacific Highway, including:

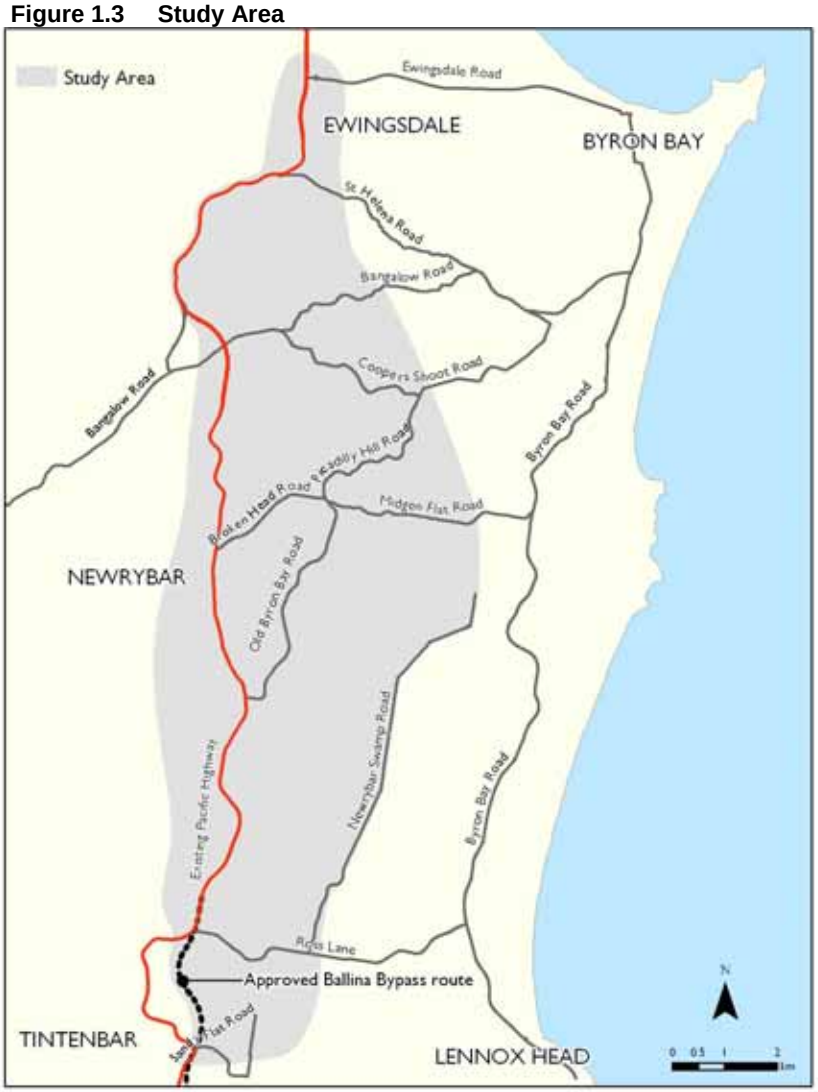
- *North Coast Road Strategy* (RTA 1992).
- *North Coast Urban Planning Strategy* (Department of Planning, DoP, 1995).
- *Pacific Highway: Managing the Impact of Delay* (RTA 1999b).
- *Northern Pacific Highway Noise Taskforce Report* (RTA 2003a).
- *Pacific Highway Safety Review* (RTA 2004b).
- *Pacific Highway Urban Design Framework* (RTA 2005a).
- *Draft Far North Coast Regional Strategy* (DoP 2006).

1.3 Study Area

The Tintenbar to Ewingsdale project commenced in October 2004 with the announcement of the original study area. The expanded study area was publicly announced in April 2005. The boundaries of the adopted study area (see **Figure 1.3**) are:

- South to North: Sandy Flat Road, just south of Tintenbar, north to the Ewingsdale residential area; a distance of approximately 23 km following the existing Pacific Highway.
- West: generally 0.5 km west of the existing Pacific Highway.
- East: Newrybar Swamp Road in the coastal flats, then up the coastal escarpment.

Figure 1.3 Study Area



1.4 Project Objectives and Design Standards

1.4.1 Pacific Highway Upgrade Program Objectives

The Pacific Highway Upgrading Program aims to:

- Significantly reduce road accidents and injuries.
- Reduce travel times.
- Reduce freight transport costs.
- Develop a route that involves the community and considers their interests.
- Provide a route that supports economic development.
- Manage the upgrading of the route in accordance with Ecologically Sustainable Development (ESD) Principles.
- Provide the best value for money.

1.4.2 Tintenbar to Ewingsdale Project Objectives

Project specific objectives are listed in **Table 1.1**. These objectives were developed with the input of the Community Liaison Group (CLG) established for the project.

Table 1.1 Project Objectives

RTA Program Objectives	Project Objective
Significantly reduce road accidents and injuries	• Develop a project that meets the following design criteria: – Four-lane divided carriage between Ross Lane and Ewingsdale joining the northern end of the proposed Ballina Bypass and the existing dual carriageway roadway at Ewingsdale with potential to expand to six lanes if required with minimal disruption. – Grade separation of local roads and the proposed highway. – Limited access conditions, i.e. no private access points along the proposed highway upgrade. – Concept design for a 110 km/h design speed for the vertical alignment and 110 km/h design speed for the horizontal alignment. – Concept design that incorporates pedal cyclists' requirements. • Develop a project with a target crash rate of a maximum of 15 crashes per 100 million vehicle kilometres travelled over the project length. • Develop a project that retains or replaces existing rest areas within the study area and is consistent with RTA policies on rest areas. • Where possible, improve safety of travel on the existing Pacific Highway (through the study area) until the proposed upgrade is operational.
Reduce travel times	• Develop a project that reduces travel time for Pacific Highway traffic. • Develop intersections and interchanges designed to at least a Level of Service C, 20 years after opening for the 100th Highest Hourly Volume. • Develop a project that provides adequate flood immunity on at least one carriageway, target 1:100 year flood event. • Develop a project that minimises disruption and delay during construction.

RTA Program Objectives	Project Objective
Reduce freight transport costs	• Develop a project that reduces overall freight transport costs. • Develop a project that meets freight transport vehicle requirements.
Develop a route that involves the community and considers their interests	• Meet the objectives of the Community Involvement Plan and the CLG. • Seek the experience, expertise, and input of the community to better inform each stage of the upgrade process. • Adopt a policy of transparency in the development and assessment of route options. • Investigate feasible routes in the initial stages of the study. • Minimise uncertainty in affected communities by undertaking the route selection process as efficiently as possible. • Mitigate the impact of noise levels associated with the project (including engine braking noise), and meet the Environment Protection Authority Target Noise Levels where it is reasonable and feasible to do so and implement the adopted recommendations from the Northern Pacific Highway Noise Taskforce. • Develop a project that takes account of air quality concerns at locations of sensitive receptors. • Develop a project that minimises impacts on the scenic value of the area. • Develop a project that is enjoyable for users, but minimises impacts on nearby residents. • Develop a project that minimises the physical impacts of the route, including community severance and access patterns. • Develop a project that minimises the impact on property. • Develop a project that minimises the impacts on heritage (indigenous and non-indigenous) places.
Provide a route that supports economic development	• Develop a project that minimises the impacts on prime agricultural lands. • Develop a project that improves accessibility for local industries, utilities and emergency services. • Develop a project that minimises the impacts on businesses dependent on Pacific Highway traffic.
Manage the upgrading of the route in accordance with ESD principles	• Develop a project that minimises the impacts on sensitive ecological constraints. • Assess route options with consideration of environmental, social and economic evaluation criteria. • Apply RTA and Department of Environment and Conservation (DEC) Guidelines for managing environmental issues (biodiversity, water quality, Acid Sulfate Soils). • Assess and address cumulative environmental impacts. • Develop a project that addresses environmental safeguards and measures necessary to mitigate environmental impacts.
Provide the best value for money	• Minimise the Whole of Life Costs of the project. • Maximise the use of the existing road reserve and other road assets for duplicated sections of the project where possible.

1.4.3 Highway Design Standards

The design standards for the Tintenbar to Ewingsdale upgrade of the Pacific Highway are comprehensive and incorporate the standards and guidelines required to achieve the program goals and project objectives. They particularly relate to road safety and overall performance in terms of design life, level of access, level of service and flood immunity. They are based on the draft design standards that have been adopted for the Pacific Highway Upgrading Program.

The primary design criteria for the upgrading of the Pacific Highway from Tintenbar to Ewingsdale are defined in the following documents:

- *Upgrading the Pacific Highway, Upgrading Program beyond 2006, Draft Design Guidelines Issue* 1.2 (Draft Upgrading Pacific Highway Design Guidelines) (RTA 2005b).
- *Austroads standards, including Rural Road Design – A Guide to the Geometric Design of Rural Roads* (Austroads 2003).
- *Road Design Guide* (RTA 1996) including various updates.
- *Grade Separated Interchanges* (A Design Guide) (NAASRA 1984).

Key standards applying to this project are summarised in **Table 1.2** and a typical cross-section for the upgraded highway is shown in **Figure 1.4**.

Figure 1.4 Typical Cross Section

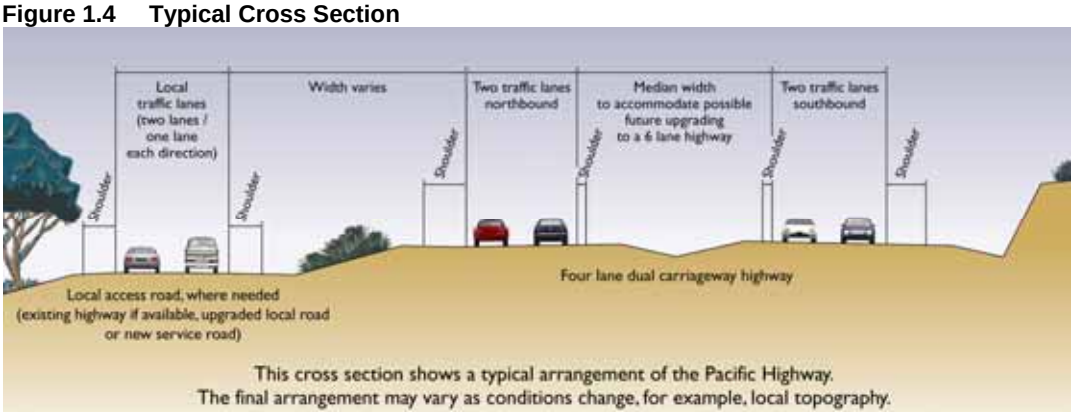


Table 1.2 Road Design Standards

Feature	Upgraded Highway	Other Local
Design speed	110 km/h horizontal and 100 km/h vertical	100, 80 and 60 km/h dependent on function
Cross section	Dual carriageway with two 3.5 m wide lanes, inner shoulders 0.5 m, outer shoulders 2.5 m, minimum median width varies from 2.6 m to 12 m depending on median barrier type	Two lane single carriageway with maximum 2 m shoulders dependent on road function
Vertical grades	Desirable maximum grade 4.5% Absolute maximum grade 6% (desirable maximum length 500 m) Climbing lanes may be required depending on length of sustained grades above 4.5%	Not specified, refer *Road Design Guide* (RTA 1996)
Flood immunity	1% Average Exceedance Probability (AEP) desirable or 5% AEP absolute minimum across floodplain. Effects of Probable Maximum Flood (PMF) to be assessed	No change to existing conditions
Intersections	Grade separated, no at-grade intersections permitted	At-grade
Access to highway	Restricted	Unrestricted
Local access	Alternative routes to be provided	Service roads or local arterial road networks to provide alternative routes for local traffic
Clearances above highway	5.3 m for the full road width including shoulders (5.3 m for any pedestrian bridges) 7.5 m above railway	5.3 m desirable, 4.6 m minimum

Further details of the proposed design criteria are described below:

- The Tintenbar to Ewingsdale upgrade will be designed as a 'M Class' upgrade as designated in the Draft Upgrading Pacific Highway Design Guidelines. Development of the highway must include a strategy for the future upgrade from 2 to 3 lanes in each direction, if needed. The preferred strategy is to widen within the median; and median widths are set accordingly. The minimum width of 11.5 m for bridges is required where additional width cannot be added later and provided there is off-road provision for cyclists (30 years, whole of life analysis). A strategy must be developed and approved by the Pacific Highway Office if there is no off road provision for cyclists.
- Median widths dependant on assessed requirement for future widening as well as type of median barrier/fencing. Generally, the desirable minimum median width is 12 m to accommodate future possible widening to three lanes in each direction, if needed. The minimum median width is 5 m with wire rope barrier or 2.6 m with concrete median barrier subject to provision for widening on nearside (outside). Wider medians and/or independent carriageways should be considered where appropriate for example to preserve vegetation or provide a visual feature.
- Meet or exceed B-Double vehicle requirements as a through route, and, where appropriate, design interchanges and intersections for B-Double usage. However, there are currently no designated B-Double routes in the study area apart from the existing Pacific Highway and,

assuming the upgraded highway is on a new alignment, it is expected that the old highway would lose its status as a B-Double route on opening of the upgrade.

- Interchanges and intersections with the highway to achieve Level of Service C or better in accordance with Austroads Traffic Engineering Practice Series Part 2 for the 100th Highest Hourly Volume, 20 years after opening.
- Lighting where safety standards require, such as at intersections and interchanges.

1.4.4 Ecologically Sustainable Development (ESD)

Sustainability principles outlined in both NSW and Commonwealth legislation will be considered in the upgrading of the Pacific Highway.

ESD is given further definition and planning impetus through the Byron Local Environmental Plan (LEP) (Byron Shire Council 1988, as amended). The Plan has as its aim to promote sustainable development within Byron Shire.

Application of ESD principles began in the early stages of the project through the identification of highway development constraints in the study area. These constraints guided the development of route options and the selection of the preferred route. Social, environmental and design evaluation criteria used in the project also reflect the ESD principles.

1.5 Planning Context

1.5.1 Statutory Planning

State Environmental Planning Policies

A large number of the State Environmental Planning Policies (SEPPs) apply to both Ballina and Byron LGAs; however, the SEPPs that are particularly relevant to route selection and assessment of the preferred route are as follows:

- *State Environmental Planning Policy No. 4 - Development Without Consent and Miscellaneous Exempt and Complying Development* (SEPP 4). Under SEPP 4, developments for the purpose of classified roads or proposed classified roads (as defined by the Roads Act 1993) are exempt from the need to obtain development consent under Part 4 of the EP&A Act. Where development consent is required under an LEP, a proposed classified road, such as the Tintenbar to Ewingsdale Pacific Highway upgrade, may be subject to an environmental assessment under Part 5 of the EP&A Act.
- *State Environmental Planning Policy No. 14 - Coastal Wetlands* (SEPP 14). Designated SEPP 14 Coastal Wetlands occur within the two Council areas. SEPP 14 aims to ensure that coastal wetlands are preserved and protected in the environmental and economic interests of the State. Any part of a road proposal affecting a SEPP 14 wetland is classified as designated development and requires Council consent under Part 4 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act). The portion of a proposal classified as designated development under SEPP 14 requires the preparation of a Development Application accompanied by an environmental impact statement under Part 4 of the EP&A Act to be submitted to the relevant Council.
- *State Environmental Planning Policy No. 26 - Littoral Rainforests* (SEPP 26). This SEPP protects littoral rainforests and requires that the likely effects of proposed development are considered in an Environmental Impact Statement (EIS). The policy applies to 'core' areas of littoral rainforest as well as a 100 m wide 'buffer' area surrounding these core areas, except for residential land and areas to which SEPP 14 applies.
- *State Environmental Planning Policy Major Projects* (Major Project SEPP) (gazetted August 2005). This SEPP defines certain developments that are major projects under Part 3A of the EP&A Act and, as a result, are determined by the Minister for Planning.

North Coast Regional Environmental Plan

The *North Coast Regional Environmental Plan* (DoP 1988) established a regional framework for the development of the NSW North Coast Region. The *North Coast Urban Planning Strategy* (DoP 1995) provides a more detailed implementation framework based on the provisions of the NCREP.

Local Environmental Plans

Legislation has been passed that requires all LGA's to have a LEP. The plan should consider the future growth of the region, land use planning and environmentally acceptable and unacceptable development. Once approved by Council and the Minister for Planning, a LEP becomes an important environmental planning instrument.

The proposed Tintenbar to Ewingsdale highway upgrade falls within the two local government areas of Ballina and Byron Shire Councils and is therefore subject to two LEPs.

Byron Shire Council LEP

The northern portion of the study area for the Tintenbar to Ewingsdale section of the proposed Pacific Highway upgrade is located within Byron Shire LGA. The Byron Council LEP requires any development proposal to demonstrate that it is consistent with overall aims and objectives of the LEP as well as any zone objectives.

The majority of the study area in Byron Shire is land zoned for agriculture – 1(a) General Rural Zone, 1(b1) and 1(b2) Agriculture Protection Zones. Bangalow village is predominately covered by the 2(a) Residential Zone and the escarpment at St Helena is covered by the 7(d) Scenic Escarpment Zone. Within the study area near Ewingsdale, the land is zoned as either 1(c2) Small Holdings Zone or 1(d) Investigation Zone. Roads are not prohibited in any Byron LEP zones in the study area.

Ballina Shire Council LEP

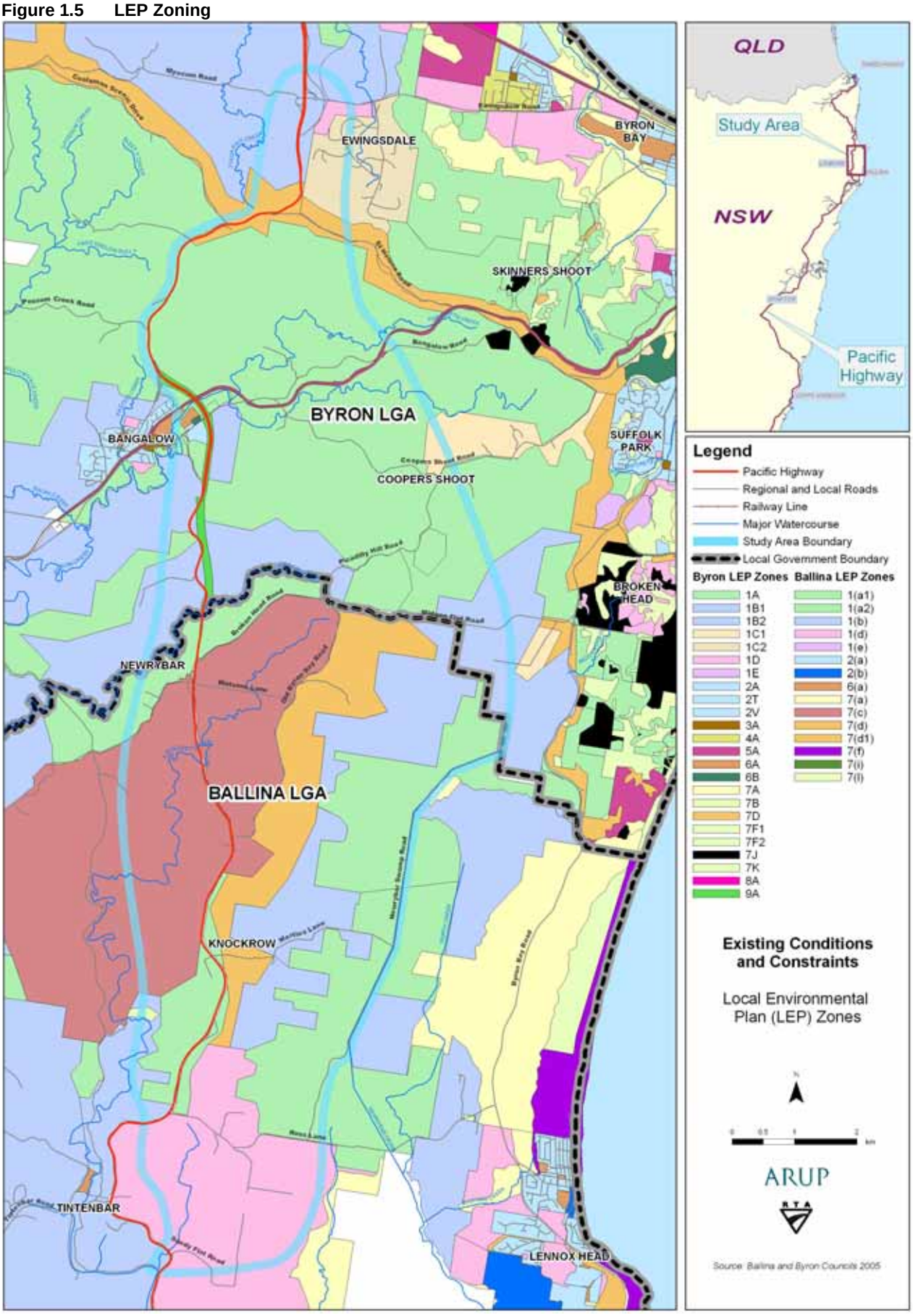
The southern portion of the study area is located within Ballina Shire LGA. The Ballina Shire Council LEP is a performance based planning instrument which requires any development proposal to demonstrate that it is consistent with overall aims and objectives as well as any zone objectives.

The study area within Ballina Shire includes Zones 1(a1) Rural (Plateau Lands Agriculture), 1(a2) Rural (Coastal Lands Agriculture), 1(b) Rural (Secondary Agricultural Land), 1(d) Rural (Urban Investigations), 6(a) Open Space, 7(a) Environmental Protection (Wetlands), 7(c) Environmental Protection (Water Catchment), 7(d1) Environmental Protection (Newrybar Scenic/Escarpment). Roads are not prohibited in any of the Ballina LEP zones in the study area.

In Ballina Shire, the land zoned 1(d) in the south of the study area has been identified in the Ballina Urban Release Strategy 2000 as an area for investigation for future urban expansion. The strategy does not identify actual areas for development and no rezoning has occurred in the study area to date. The northern section of the 1(d) zone is known as the Cumbalum Ridge.

Figure 1.5 shows the relevant zonings within Byron Shire and Ballina Shire Council areas.

Figure 1.5 LEP Zoning



1.5.2 Non-Statutory Planning

There are a number of non-statutory growth strategies that are either in place or being developed for the area relating to the Tintenbar to Ewingsdale upgrade. These strategies are not binding to the degree of the SEPPs, Regional Environment Plans (REPs) and LEPs, yet are very important as they are expressions of long term plans of development for certain areas and are part of the Councils' long term vision.

The following settlement strategies, policies and development control plans are relevant to the study area:

- *Draft Far North Coast Regional Strategy* (DoP 2006).
- *Northern Rivers Farmland Protection Project* (Department of Planning and Natural Resources, DIPNR 2005).
- *Cumbalum Structure Plan* (Ballina Shire Council 2006).
- *Ballina Shire Urban Land Release Strategy* (Ballina Shire Council 2000).
- *Development Control Plan No. 12: Newrybar Scenic Escarpment* (Ballina Shire Council 2003).
- *Byron Bay and Suffolk Park Settlement Strategy* (Byron Shire Council 2002).
- *Draft Place-Based Plan for Ewingsdale* (Byron Shire Council 2003a).
- *Bangalow Settlement Strategy* (Byron Shire Council 2003b).
- *Byron Shire Community Profile* (Byron Shire Council 2003c).
- *Byron Shire Sustainable Agriculture Strategy* (Byron Shire Council 2004).

Draft Far North Coast Regional Strategy

The *Draft Far North Coast Regional Strategy* applies to the six local government areas of Ballina, Byron, Kyogle, Lismore, Richmond Valley and Tweed. It builds on previous planning work including the *Northern Rivers Regional Strategy* and local council settlement strategies. It recognises the rapid growth of South East Queensland and its potential impacts by planning to maintain the character of the region, protect its important environmental assets and provide economic opportunities.

The purpose of the regional strategy is to manage expected growth in a sustainable manner; while protecting the unique environmental assets, cultural values and natural resources of the region. The draft strategy does not identify future regional infrastructure needs. It will, however, inform work undertaken by the government for investment priorities for the Far North Coast and the timing of the provision of such infrastructure. Infrastructure planning will take into account the broad planning framework (including the location and types of urban centres, housing and employment lands identified in the strategy), to ensure that future population growth is supported by essential human services and associated infrastructure.

Once finalised, the strategy will be implemented by requiring that Local Environmental Plans are updated to be consistent with the outcomes and actions of the strategy.

Northern Rivers Farmland Protection Project

The NSW State Government, through DoP and the Department of Natural Resources (DoNR) - formerly Department of Infrastructure, Planning and Natural Resources (DIPNR) - and the Department of Primary Industries (DPI), has recognised the need to protect agricultural land particularly in those areas facing increasing development pressure. The Northern Rivers Farmland Protection Project has identified areas to be reserved for agricultural land to secure its future growth and development in the Northern Rivers area. *Direction No. 14 – Farmland of State and Regional Significance on the NSW Far North Coast* under Section 117 (2) of the EP&A Act was issued on 30 September 2005 and contains provisions restricting the rezoning of significant farmland for urban or rural residential purposes. The

Northern Rivers Farmland Protection Project – Final Recommendations (DIPNR 2005) provides guidance and background regarding the Farmland Protection Project.

Cumbalum Structure Plan

In March 2006, Ballina Shire Council released the *Draft Cumbalum Structure Plan* for public exhibition. The structure plan sets the policy context to guide detailed technical studies to be undertaken for re-zoning of land, in accordance with statutory requirements.

The structure plan provides the opportunity for the community, through Council, to guide the development of the Cumbalum Ridge in a manner consistent with community expectations. Principally the structure plan establishes a vision and set of development objectives, which future development proposals will be required to meet. The structure plan also outlines 'concept precinct plans' of individual precincts, which broadly indicate the likely future development potential within a precinct, including concept land uses for residential, recreation, special uses, and tourist accommodation.

In July 2006, the Council adopted the plan as the Council's strategic planning framework for the Cumbalum Urban Release Area.

Byron Rural Settlement Strategy

In the *Byron Rural Settlement Strategy*, Byron Shire has identified an area known as Natural Lane for future rural residential development. This area is located to the north of Midgen Flat Road and below the escarpment in the vicinity of Granny Waterhouse Drive. It is currently zoned 1(a) and has the potential for 70 dwellings. Although the strategy is currently under review, the Council has the expectation that this land would be used for rural residential development in the future.

1.5.3 Planning Approvals Process

Changes to the Environmental Planning and Assessment Act 1979

The NSW Parliament passed the *Environmental Planning and Assessment Amendment (Infrastructure and Other Planning Reform) Act 2005 No 43* on 16 June 2005. This amendment came into force on 1 August 2005.

The amendment introduces a new Part 3A to the EP&A Act to cover the assessment of major infrastructure development. This type of development was previously assessed under Part 4 and/or Part 5 of the EP&A Act.

Application of Part 3A of the EP&A Act

By an order gazetted on 29 July 2005, the Minister for Planning declared that Part 3A applies to all projects for which the proponent is also the determining authority and which otherwise would have required an EIS to be obtained under Part 5. Within the meaning of Part 5 of the EP&A Act, the RTA is both the proponent and the determining authority for the Tintenbar to Ewingsdale Project and assessment of the preferred route is required under Part 3A (see **Section 8.6.1**). Prior to the Part 3A application, the RTA had determined that an EIS would be required on the Tintenbar to Ewingsdale Project.

1.6 Community and Stakeholder Involvement

1.6.1 Community Involvement

A comprehensive community and stakeholder involvement program was established for this project. Community involvement was undertaken during key stages of the project to ensure effective stakeholder involvement. The community involvement process for the project is outlined in **Table 1.3**.

The community has provided a wealth of local knowledge that has been reviewed and considered by the Project Team. Community submissions were received by email, fax and the project information line, as well as through individual property visits and meetings. These submissions were collected and analysed to achieve an understanding of the impacts facing the local community.

A Community Liaison Group (CLG) was formed with an original group of 30 members, and then re-formed to include members of the community to represent the expanded study area. The CLG was committed to providing input to the route development and selection process.

In addition, Agricultural Focus Group (AFG) members played a key role in highlighting the issues associated with agriculture and land use, particularly in relation to the identification of constraints, evaluation criteria and the development of corridor options in the study area.

Submissions from the public were called for during the public display of the RODR. There were a total of 19,150 submissions received during and after the route options display. The initial four week submissions period was extended to six weeks (21 October 2005 to 2 December 2005). These submissions are discussed in **Chapter 4** of this report and in more detail in the *Route Options Submissions Report* (RTA May 2006).

Additionally, the CLG and the broader community have raised a number of important issues regarding the planning process and the overall direction of the project. These included broad issues such as the extent of the study area and the project objectives, through to specific concerns regarding the assessment methodology and implementation. Key issues that have been raised to date by the CLG and the broader community (outside of the formal public display period) are listed in **Appendix A**. Overall, there has been a high level of community interest and involvement in the project.

Table 1.3 Community Involvement

Project Stages	Communication Strategy Components
Project familiarisation	Community Information Sessions
	Project information (freecall) line number, email, freepost establishment
	Website development
	Community Update No. 1
	Progress updates in local media
	Project Team attendance at community meetings
	Planning Focus Meeting
	Agency Requirements
	CLG and AFG set-up and initial meetings
	Property owner meetings and direct contact
Route option assessment	Community Update No. 2
	Route Options Display and information sessions
	Project information line
	Planning Focus Meeting
	CLG/AFG meetings
	Progress updates in local media
	Project Team attendance at community meetings
	Corridor Assessment Workshop
	Property owner interviews and direct contact
Route selection	Value Management Workshop
	Community Update No. 3
	Preferred Route Display
	CLG/AFG meetings
	Property owner interviews and direct contact

1.6.2 Government Agency and Other Stakeholder Involvement

Government agency representatives, regional and local organisations, and other stakeholders provided input and feedback to the Project Team at key stages of the project.

Planning Focus Meetings were held in November 2004 and February 2005. A Corridor Assessment Workshop was held in August 2005, and a Value Management Workshop (VMW) was held in December 2005. Stakeholder groups invited to attend meetings and workshops included:

- State Government agencies including: Ambulance Service of NSW; Australian Heritage Council; Australian Rail Track Corporation; Department of Commerce; Department of Education; DEC; Department of Environment and Heritage; DIPNR; DPI; National Parks and Wildlife Service (now part of DEC); NSW Police Force; NSW Rural Fire Service; Rural Lands Protection Board; State Emergency Service; and Rail Infrastructure Corporation.
- Ballina Shire Council, Byron Shire Council and Rous Water.
- Aboriginal groups including: Bundjalung Elders Council; Burabi Aboriginal Corporation; Byron Tweed Local Aboriginal Land Council; Jali Local Aboriginal Land Council; and Tweed Byron Local Aboriginal Council.
- Service providers including: Country Energy; Optus; Telstra; Transgrid; and Kirklands Coaches.
- Other stakeholders including: Bangalow Public School; Newrybar Public School; Northern Rivers Catchment Management Board; Northern Rivers Regional Development Board; NSW Sugar Mill Cooperative; and CLG members.

Several of the groups invited did not attend the meetings and/or the workshops. Other meetings with Aboriginal stakeholders were held to discuss Aboriginal heritage constraints and to establish an Aboriginal Focus Group.

During the public display of the RODR, submissions were received from agencies including: DEC, DPI, DoP, Ballina Shire Council, Byron Shire Council, Northern Rivers Regional Development Board, Rous Water and Jali Local Aboriginal Land Council. Their concerns are summarised in **Chapter 4** of this report.

Additionally, since the public display of the route options, the Project Team has met with the Ewingsdale Progress Association and other members of the Ewingsdale community to discuss noise concerns.

1.6.3 Summary of Community, Agency and other Stakeholder Involvement

Table 1.4 and **Table 1.5** provide a summary of community consultation and agency and other stakeholder involvement from commencement of the project to March 2006.

Table 1.4 Summary of Community Consultation

Meeting	Date	Key Discussion Topic(s)
Community Information Sessions (CISs)		
CIS 1	12 Nov 04	Project announcement and introduction, project objectives and constraints workshops.
CIS 2	15 Nov 04	Project announcement and introduction, project objectives and constraints workshops.
CIS 3	16 Nov 04	Project announcement and introduction, project objectives and constraints workshops.
CIS 4	20 April 05	Expanded study area announcement, project status and constraints workshops.
CIS 5	21 April 05	Expanded study area announcement, project status and constraints workshops.
Community Liaison Group		
CLG 1	15 Dec 04	Introduction, draft CLG Charter, project objectives and status update.
CLG 2	24 Jan 05	Discussion about independent facilitator, access to property for field investigations, Draft CIS report tabled and draft CLG Charter reviewed.
CLG 3	7 Feb 05	Further discussion about independent facilitator and CIS report, project objectives, meeting procedure issues, vote of no confidence, AFG report and update on project milestones.
CLG 4	7 Mar 05	Further discussion about independent facilitator, vote of no confidence, noise presentation, design criteria presentation, project progress and project objectives.
CLG 5	18 Apr 05	Announcement of expanded study area and process for re-forming CLG.
CLG 5A	16 May 05	New CLG members briefing, study process and review of past meetings and outcomes.
CLG 6	30 May 05	Review of expanded study area, Ballina Bypass, and revised CLG Charter and project objectives.
CLG 7	31 May 05	Overview of evaluation process, constraints mapping, pairwise process and discussion on evaluation criteria.
CLG 7A	21 June 05	Noise presentation by Arup Acoustics, questions and answers.
CLG 8	27 June 05	Overview of constraints identification and classification process and constraints presentations from each of the subconsultants.
CLG 9	28 June 05	Finished constraints presentation and provided information about the Corridor Assessment Workshop.
CLG 10	18 July 05	Presented final draft evaluation criteria and reviewed the confidentiality commitments prior to displaying the long list of options at CLG 11.
CLG 11	20 July 05	Presented long list of options and nominated Corridor Assessment Workshop attendees.
CLG 12	22 Aug 05	Discussion about confidentiality issues, route options display preparation, and CLG rep summaries from Corridor Assessment Workshop.
CLG 13	19 Sep 05	Presentation of geotechnical, noise and route options assessment draft working papers.
CLG 14	2 Nov 05	Discussion about the route options display and shortlisting process, introduced the VMW in December 05.

Meeting	Date	Key Discussion Topic(s)
CLG 15	14 Nov 05	Value management overview presentation, assessment process for long list to short list presentation and workshop to identify CLG advantages and disadvantages of short list for VM.
CLG 16	15 Feb 06	Review of VMW and route options display. Also a review of the preferred route selection process.
CLG 17	28 Mar 06	Presentation of initial results of agricultural assessment, including regional economic modelling, and noise impact assessment.
CLG 18	26 Apr 06	Presentation of hydrology assessment, property acquisition policies and processes, and results of the *Route Options Submissions Report*.
Agricultural Focus Group		
AFG 1	21 Feb 05	Introductions and discussion about agricultural constraints and opportunities.
AFG 2	23 Mar 05	DIPNR presented an overview of the Farmland Protection Project and DPI presented agricultural land classification.
AFG 3	26 April 05	Information on major agricultural industries presented.
AFG 4	14 June 05	Further discussion about Farmland Protection project, presentation by CLG members and discussion on Project Team agricultural industries presentation.
AFG 5	1 Aug 05	Presentation of agricultural evaluation criteria.
AFG 6	20 Sep 05	Discussion about value added business and CLG member presentation on valuing agricultural land.
AFG 7	8 Nov 05	Presentation of assessment process from long list to short list, AFG nomination for VMW and proposed agriculture assessment process methodology.
AFG 8	12 Dec 05	Presentation of agricultural assessment process and evaluation criteria for selection of the preferred route.
AFG 9	20 Feb 05	Presentation of the methodology and preliminary results of the agricultural assessment and regional economy modelling.
AFG 10	3 Apr 06	Presentation of the regional economic modelling, including methodology, the role of the Tweed Economic Corporation and the preliminary results.
Aboriginal Focus Group		
AbFG 1	14 Nov 05	Project update for Aboriginal stakeholders, including discussions of the methodology and outcomes of Aboriginal heritage investigations, route options display and VMW.
Ewingsdale Progress Association and Ewingsdale Residents		
	16 Feb 06 29 Mar 06	Meetings were held to discuss concerns with tunnel options T1 and T2. Concerns included: noise impacts of tunnel options and associated local roads; noise mitigation measures; noise impacts for residences on Plantation Drive; and tunnel grades.

Table 1.5 Summary of Agency and Other Stakeholder Involvement

Date	Meeting
16 Nov 04	Planning Focus Meeting 1
15 Feb 05	Planning Focus Meeting 2
2-3 Aug 05	Corridor Assessment Workshop
21 Oct 05	Rous Water
27 Oct 05	Ballina Shire Council
4 Nov 05	Byron Shire Council
14 Nov 05	Project update with Aboriginal stakeholders
12 Dec 05	Rous Water
12 Dec 05	Ballina Shire Council
12 Dec 05	Northern Rivers Regional Development Board
12 Dec 05	Department of Primary Industries
15 and 16 Dec 05	Value Management Workshop
1 Mar 06	Department of Planning
16 Feb 06	Newrybar School and Department of Education
1 June 06	Rous Water
29 Mar 06	Byron Shire Council

1.7 Purpose of This Report

This report documents the process and methodology for selection of the preferred route. It is important to note that the selection of the preferred route is based on the outcome of three independent processes (or 'streams') of work conducted on the route options, including:

- Community and agency submissions on the Route Options Display held in late 2005 and the corresponding RODR as reported in the *Route Options Submissions Report* (RTA 2006).
- The VMW for the short list of route options held in December 2005 and reported in the *Value Management Workshop Report*.
- The technical assessment of the short list of route options as reported in this document, PRR, **Chapter 6**.

1.7.1 Structure of Report

This report is structured as follows:

Chapter 1	Introduction
Chapter 2	Route Options Development
Chapter 3	Updated Work Since the *Route Options Development Report*
Chapter 4	Route Options Display Consultation
Chapter 5	Value Management Workshop
Chapter 6	Technical Assessment of the Short List of Options
Chapter 7	Selection of a Preferred Route
Chapter 8	The Preferred Route
Chapter 9	Project Costs
Chapter 10	Next Steps

2 Route Option Development

2.1 Route Option Development Process

This chapter provides an overview of the route option development process and a summary of the RODR.

2.1.1 Planning and Design Process

Route options for the Pacific Highway upgrade were developed through an iterative process involving a range of environmental and urban design, engineering, community, safety and cost considerations structured around the following route option stages:

The process for the development and assessment of route options as well as the relationship of project phases to key reports and workshops is shown in **Figure 2.1**.

The process, described in detail in the RODR, incorporates consultation with the community, government agencies, and other stakeholders to provide input into the process and feedback from studies and investigations. Consultation activities associated with the project to date are described in detail in **Section 1.6**.

2.2 Development of Initial and Long List of Route Options

Using interactive computer modelling and constraints mapping, it was possible to investigate a large number of possible route options.

A broad range of route options extending across the study area were initially investigated. Route options were progressively adjusted to avoid as many constraints as possible while still achieving the design criteria and maintaining project objectives and functionality. The resulting long list of route options was made up of sections. Through the multiple combinations of the various sections, it was possible to develop over 200 route options from the long list (see **Figure 2.2)**.

Figure 2.1 Process Diagram

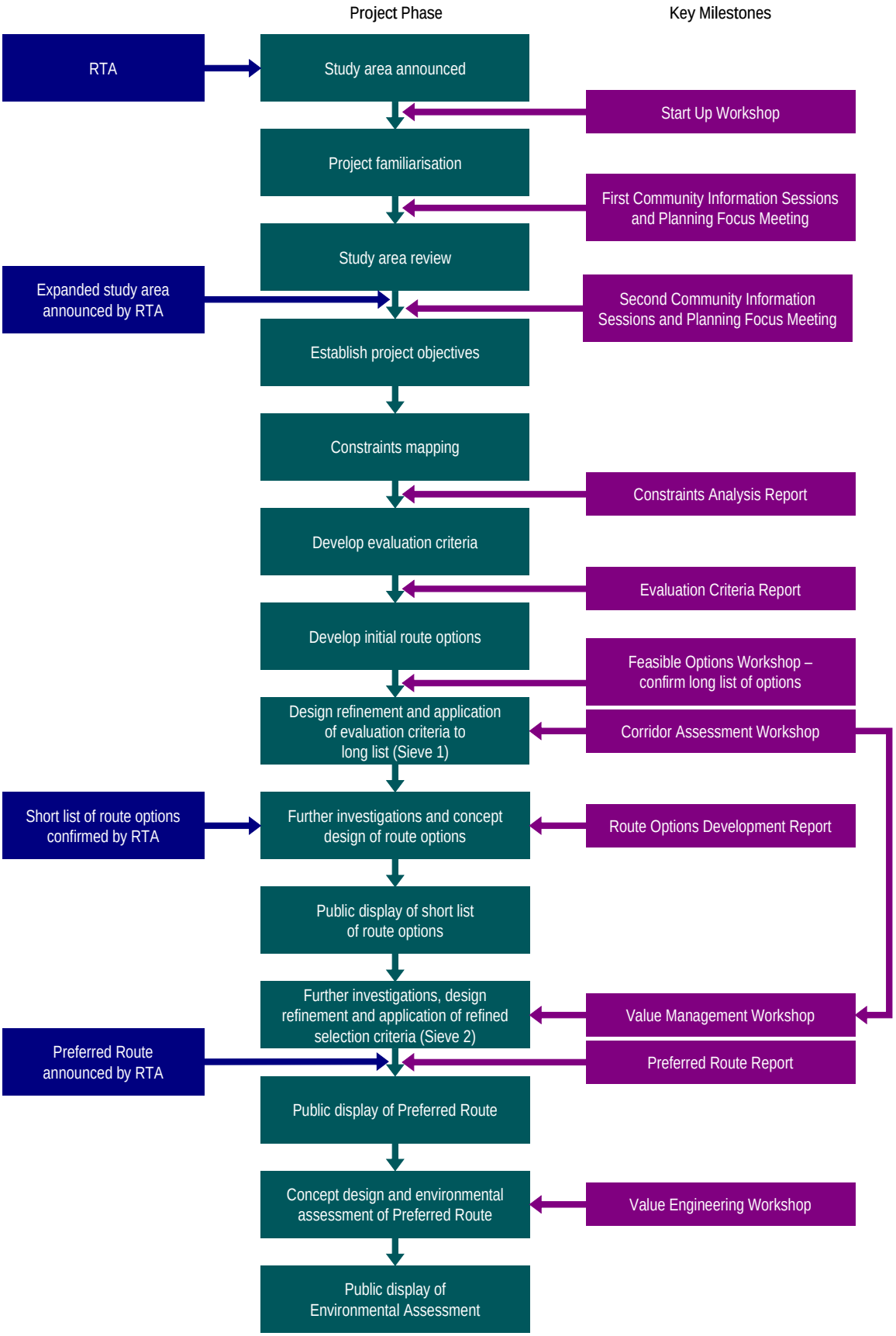
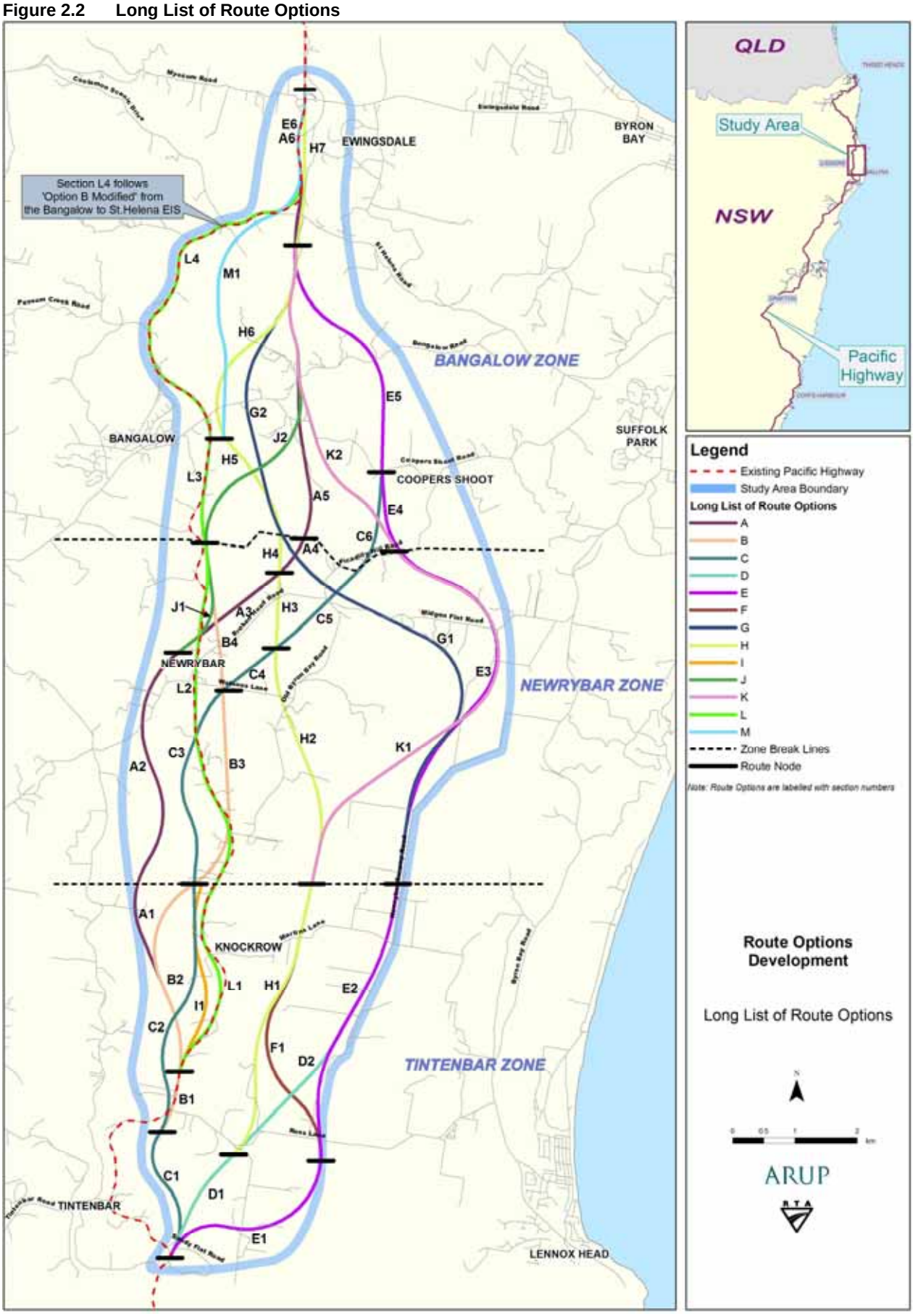


Figure 2.2 Long List of Route Options



2.3 Assessment of Long List of Route Options and Selection of Short List

2.3.1 Methodology

The process adopted to evaluate and rank the long list of route options included two steps:

- Assessment of the performance of each section against the Sieve 1 evaluation criteria with the Project Team's pairwise weightings used as the base case.
- Application of pairwise weightings from the CLG and government agencies to test the sensitivity of performance of each option. The pairwise process involves taking one evaluation criterion/measure at a time and selecting whether it is of more or less importance than every other criterion/measure.

The assessment of the long list of options was based on a generic corridor width of 250 m and details of the assessment are included in the RODR. The resulting short list of route options is shown in **Figure 2.3**.

2.3.2 Option B Modified from Bangalow to St Helena EIS

The section of the Pacific Highway from Bangalow to St Helena was the subject of an EIS that was placed on public exhibition in 1999. The preferred route in that EIS, referred to as Option B, generally followed the existing highway. Northern Pacific Highway Noise Taskforce recommendations (RTA 2003a) were the catalyst for further review of this Option B. Additionally, the *Bangalow to St Helena Pacific Highway Upgrade Submissions Report, Volumes 1 and 2* (RTA 2004a) outlined concerns of the Bangalow to St Helena EIS preferred route. Thus, Option B Modified was reassessed as part of the long list of route options in the RODR; referred to as Section L4 (see **Figure 2.2**).

The RODR long list assessment results showed that the two options incorporating Section L4 were rated lowest of the Bangalow zone options, regardless of the weightings applied. Particular issues that contributed to the relatively poor ranking of options incorporating Section L4 were:

- It does not meet the highway design standards established for the upgrade.
- It would force local traffic to share the upgraded highway, as it would not be possible to retain the existing highway as a separate road for local traffic usage.
- It would be between 1.2 km and 1.8 km longer than other shortlisted route options, adding to travel times for all users.
- It would require acquisition of a greater number of dwellings than any of the other Bangalow zone options.
- It performed poorly in terms of noise impacts.
- It crosses more wildlife corridors than other Bangalow zone options.

For these reasons neither of the two Bangalow zone options incorporating Option B Modified was included in the best performing Bangalow zone options taken forward for further consideration, and neither option made the short list of options.

2.4 Summary of Short List of Route Options

The assessment process, detailed in the RODR, identified the route options shown in **Figure 2.3**

Option A is an upgrade generally following the existing highway corridor, Option B is a plateau option in an entirely new corridor, and Options C and D are new corridors partly located on the eastern coastal plain. Four discrete options, made up of sections, were presented in the RODR. Additionally, two tunnel options, T1 and T2, were shortlisted. All of the route options could be connected to either tunnel option.

The key design features of the short list of options, as presented in the RODR, are provided below, and the summary of likely impacts for each of the options based on RODR corridors are listed in **Table 2.1**.

Option A – Sections A/B, A1, A2

- Plateau option that incorporates a tunnel under St Helena Hill.
- Alignment uses the approved Ballina Bypass, from Sandy Flat Road to Ross Lane.
- This alignment most closely follows the existing Pacific Highway with almost 10 km of existing road reserves being utilised.
- This alignment also uses the 9(a) proposed road reserve zone near Bangalow and the Bangalow Bypass.
- This option requires the construction of more extensive local access roads and would have high impacts on service relocations and acquisition of buildings.
- This option crosses four major creeks.

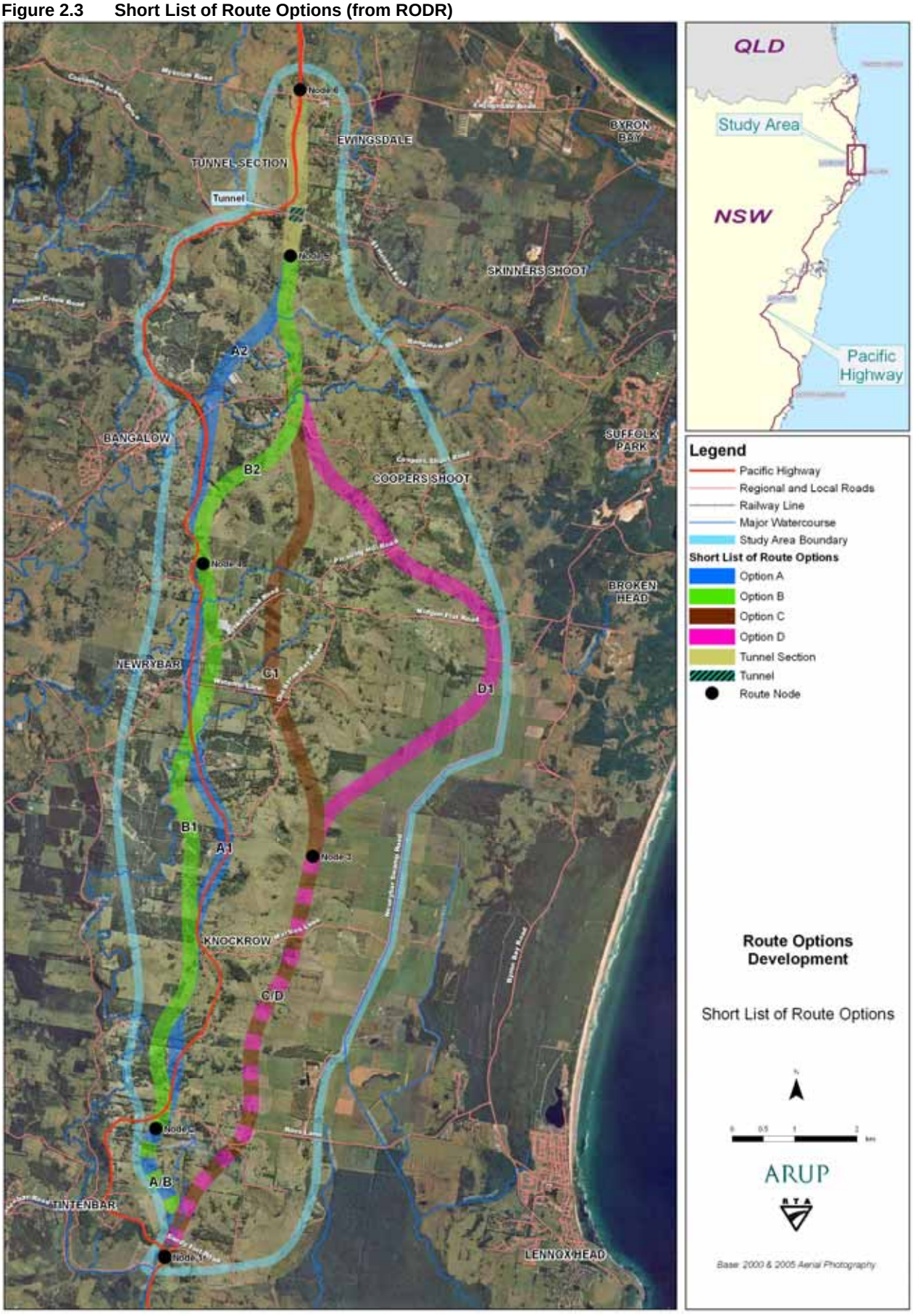
Option B – Sections A/B, B1, B2

- Plateau option that incorporates a tunnel under St Helena Hill.
- Alignment uses most of the approved Ballina Bypass, from Sandy Flat Road to Ross Lane.
- This alignment partly utilises the 9(a) proposed road reserve zone near Bangalow.
- This option uses about 5 km of existing road reserve.
- This option is slightly west of the existing Pacific Highway in the south and then switches to be slightly east of the existing highway north of Newrybar.
- This option crosses four major creeks.

Option C – Sections C/D, C1

- Coastal plain option that incorporates a tunnel under St Helena Hill.
- This option stays close to the foothills of the escarpment and then gradually climbs the escarpment by traversing the side slope.
- This option traverses an area of geological instability as it climbs the side slope of the escarpment.
- This option crosses some flood prone land and areas.
- This option has a high impact on state significant farmland and severance of currently contiguous settlements, including those along Broken Head Road and Old Byron Bay Road.
- This option crosses four major creeks.

Figure 2.3 Short List of Route Options (from RODR)



Option D – Sections C/D, D1

- Coastal plain option that incorporates a tunnel under St Helena Hill.
- This option stays close to the foothills of the escarpment prior to moving further east and climbing the escarpment via a ridge line.
- This option traverses through flood prone land and areas with potentially deep soft soils.
- This option is a longer route and is also close to the community of Coopers Shoot.
- This option crosses two major creeks.

Northern Tunnel Section

- A tunnel 200 to 300 m long under St Helena Hill.
- Two tunnel approach options were considered for this section of road on the north side of the tunnel. Approach option T1 follows the existing road and has grades of 6%. Approach option T2 is located up to 100 m east of the existing highway and has grades of about 4.5%.
- There are no significant differences between the tunnels required for these options.

Chapter 3 addresses the updated work conducted on the short list of route options since completion of the RODR.

Table 2.1 Summary of Likely Impacts for Shortlisted Route Options (from RODR)

	Route Options (Note 1) A	B	C	D
Engineering Characteristics				
Length (m)	19,792	20,152	19,721	22,049
Approximate length of tunnel (m)	200-300	200-300	200-300	200-300
Length of major bridges - highway (m)	660	880	559	0
Length of major bridges - local (m)	345	457	340	268
Length of grades exceeding 4.5% (m)	3,443	2,145	890	890
Comparative travel time for heavy vehicles (minutes)	14.9	14.8	15.1	15.0
Number of horizontal curves with radius less than minimum (750m)	1	1	0	0
Number of horizontal curves with radius less than desirable (750m-1200m)	6	4	1	1
Length (km) of route that utilises existing road reserve	9.9	4.9	2.2	2.2
Length (km) through potentially fog prone areas	7.1	5.9	10.1	14.6
Indicative Strategic Cost Estimate ($million)	400	410	400	385
Socio-Economic Characteristics				
Agriculture and Property				
Regionally Significant (DIPNR) Farmland affected (ha)	459	475	410	492
State Significant (DIPNR) Farmland affected (ha)	3	5	10	0
Agricultural land directly affected (ha)	380	428	403	484
Agricultural land indirectly affected (severance) (ha)	235	300	209	262
Number of dwellings acquired	73	34	25	20
Drinking Water Catchments - approximate length of route (m) through:				
Emigrant Creek Dam Catchment	4800	4000	1900	0
Proposed Lismore Source Water Catchment	7920	7670	6370	5970
Noise				
Absolute CNB (Note 2)	2216	1514	1168	922
Relative CNB (Note 3)	-252	-772	-1107	-1124
Visual				
Visual Sensitivity - approximate length of route (m) through:				
1. Coastal flats	0	0	3900	8400
2. Undulating hills and ridges with limited areas of mature vegetation	5400	6100	5900	5000
3. Enclosed valleys	2500	2400	2200	2300
4. Undulating hills and ridges with extended areas of mature vegetation	8000	8800	2000	600
5. Escarpment	3400	2100	5300	5600
6. Tunnel and approach cuttings	400	400	400	400
Visual Effect: approximate length of route (m) exposed to:				
1. Lower slopes and valleys on plateau	11700	12200	7500	6400
2. Exposed ridge lines with extensive vegetation cover	2700	2500	800	200
3. Coastal flats	0	0	3600	8100
4. Exposed ridge lines with limited vegetation cover	1700	2500	2000	1300
5. Escarpment	3200	2200	5200	5600
6. Tunnel and approach cuttings	400	400	400	400
Environmental Characteristics				
Terrestrial Ecology				
Number of patches of high value vegetation or habitat likely to be affected	16	20	25	25
Approximate area of high constraint vegetation crossed (ha)	16.5	18	23	17
Number of patches of medium value vegetation or habitat likely to be affected	6	6	4	7
Approximate area of medium constraint vegetation impacted (ha)	16	16.5	5.5	6.5
Number of 'edges' created through remnant and regenerated habitat areas	19	22	24	23
Number of times a regional wildlife corridor is crossed	1	1	1	1
Number of times a sub-regional wildlife a corridor is crossed	1	1	3	3
Number of recorded threatened species potentially affected	4	1	0	0
Aquatic Ecology				
Negligible or low constraint waterways crossed	27	37	51	51
Medium constraint waterways crossed	1	2	0	0
Hydrology				
Length through flood prone land (m)	870	870	5060	10230
Cultural Heritage				
Number of medium value non-Indigenous sites directly affected	1	0	0	0
Areas of potential archaeological deposits directly affected (ha)	0.4	3.7	3.6	2.8

Notes:

1. Potential impacts assessment based on tunnel Option T1 at the northern end.
2. Absolute Community Noise Burden (CNB) is a quantitative evaluation of potential annoyance caused by absolute traffic noise levels on residential receivers up to 300-500 m from a route option. Larger numbers imply a greater potential noise impact.
3. Relative Community Noise Burden (CNB) is a quantitative evaluation of potential annoyance caused by change in noise levels at residential receivers up to 300-500m from a route option. Larger numbers imply a greater potential noise impact, in this case -252 represents a greater noise impact than -1124.

3 Updated Work Since the Route Options Development Report

3.1 Overview of New Work

The process that led to the selection of the short list of route options was detailed in the RODR as summarised in **Chapter 2**. This process included preliminary investigations, identification of constraints, development of route options (up to the presentation of the short list), and the summary of the impacts associated with the short list of route options. Since the completion of the RODR, the Project Team has continued with investigations and the route development process that leads to the selection of the preferred route. This chapter summarises the work that has been conducted since the RODR that comprises the current information available for the shortlisted route options, and includes:

- Updated constraints mapping (based on additional field investigations and studies).
- Detailed agricultural studies and resulting economic impacts.
- Local and regional economic analyses.
- Design modifications made to the short list of route options.
- Predicted traffic flows for all key local roads.
- Local access arrangements for all shortlisted route options.
- Flood analysis including detailed modelling in the Newrybar Swamp area.
- Further work on concept design, resulting in the design footprint for the short list of options (including structure and drainage requirements).
- Updated project costs for the short list of route options.
- RTA policy and practices review.

3.1.1 Constraints Updating

The methodology of classifying constraints was described in the RODR and generally includes a ranking of constraints into three categories (low, medium and high) that define their significance. As a guide:

- High level constraints include areas that are designated or equate to having national or state level significance.
- Medium constraints equate to areas or features of regional level significance or equivalent.
- Low constraints equate to locally significant areas or features.

Where project constraints are not able to be mapped or classified in this manner they have been described in words.

Since the preparation and public display of the RODR, additional field investigations and studies have resulted in new information and revised constraints mapping in some areas. These investigations were done in response to issues raised by the community or agencies, or to obtain more detailed information for the purpose of assessing the short list of route options. As such, the additional investigations were not carried out across the entire study area; they generally focussed on the vicinity of the short list of route options.

3.1.2 Structure of Chapter

The updated status of the existing characteristics of the study area and the results of the new work are summarised in this chapter under the following headings:

- Natural and Cultural Environment Characteristics.
- Planning and Socio-economic Characteristics.
- Transport and Engineering Characteristics (includes geology, flooding, etc).
- Refined Concept Design.

Detailed technical reports are available for most of the additional studies conducted on the short list of route options as noted throughout this chapter.

Natural and Cultural Environment Characteristics

This section addresses the areas of:

- Terrestrial Ecology
- Aquatic Ecology
- Water Quality
- Cultural Heritage
- Air Quality

3.2 Terrestrial Ecology

This section summarises the existing conditions and constraints identified in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Terrestrial Ecology Working Paper* (RTA 2006).

Since the RODR, a preliminary listing has been made for Lowland Rainforest as an Endangered Ecological Community (EEC) on the NSW *Threatened Species Conservation Act 1995* (TSC Act). In addition, more detailed habitat assessment surveys within most vegetation patches along the shortlisted corridors were conducted by the specialist ecologists in November 2005. These inspections identified and confirmed vegetation patches and general vegetation communities and fauna habitats occurring within the study area.

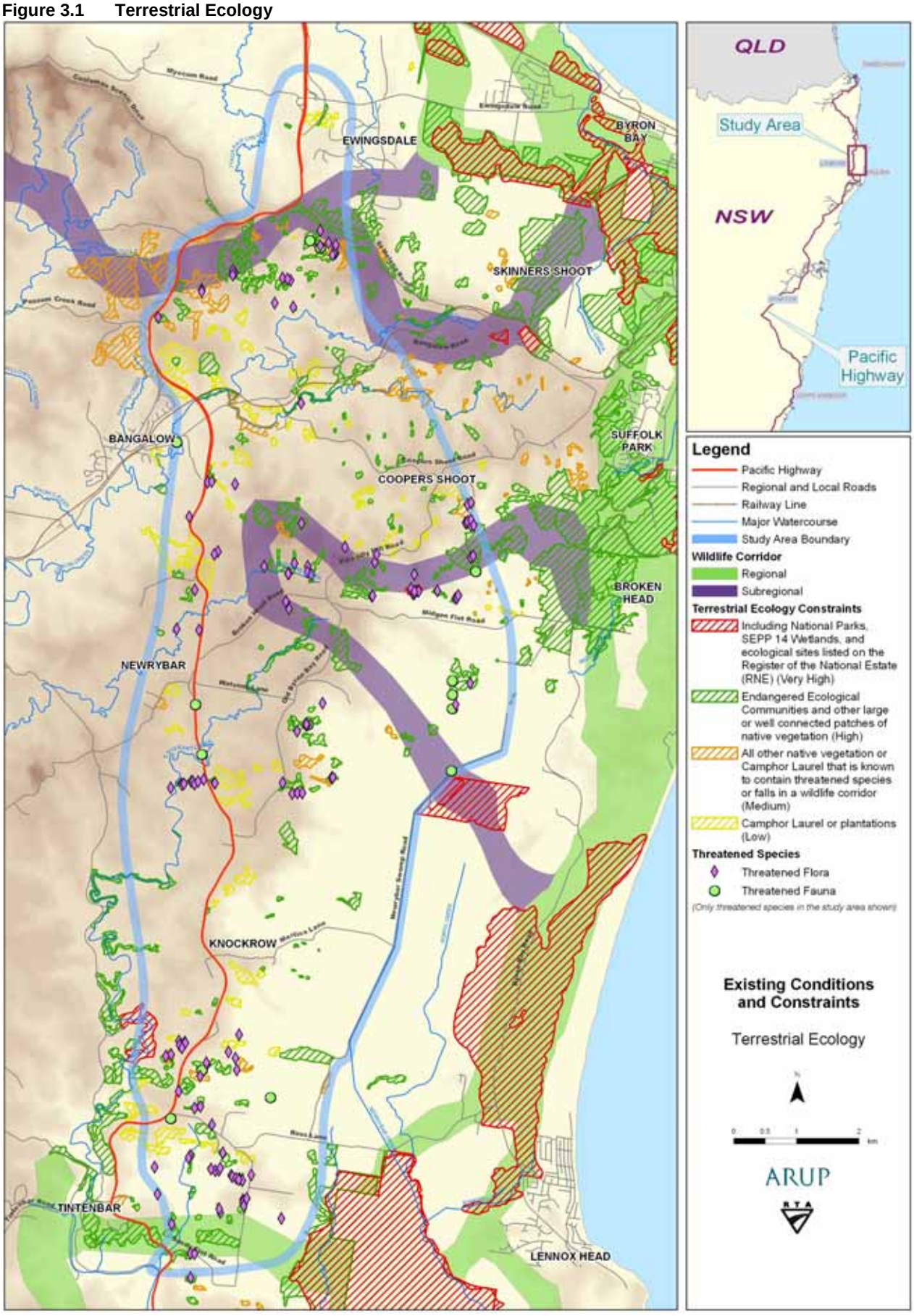
Based on the outcomes of the additional inspections and the preliminary listing of Lowland Rainforest, some of the vegetation patches in the study area have been reclassified. The updated terrestrial ecology constraints map is shown in **Figure 3.1.**

3.2.1 Plant Communities

Three EECs listed on the NSW TSC Act have been recorded within the study area, these are Swamp Sclerophyll Forest on Floodplain, Lowland Rainforest on Floodplain and Freshwater Wetlands on Coastal Floodplains. Swamp Sclerophyll Forest on Floodplain has been previously recorded in the southeast section of the study area, whereas the Lowland Rainforest on Floodplain and the Freshwater Wetlands on Coastal Floodplains have been previously recorded in the northeast part of the study area, in the Midgen Flat area.

Additionally, Lowland Rainforest, which is preliminarily listed on the TSC Act as an EEC, was recorded within the study area. Lowland Rainforest has been previously recorded along and to the west of the escarpment.

Figure 3.1 Terrestrial Ecology



Although the study area contains numerous patches of vegetation, many of these patches consist predominantly of Camphor Laurel and as such, are of relatively low conservation value. Apart from patches of Camphor Laurel and Pine and Eucalypt plantations, all locally endemic native vegetation within the study area is classified as an EEC.

No EEC listed on the Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC Act) have previously been recorded within 10 km of the study area.

3.2.2 Threatened Species

A total of 48 threatened plant species listed in the TSC and/or EPBC Acts have previously been recorded or have potential habitat within a 10 km radius of the study area.

Figure 3.1 displays the location of threatened species within the study area as derived from NSW DEC Atlas of NSW Wildlife, Ballina Council, Byron Council, landowners and field surveys conducted as part of this study.

Platypuses have been previously recorded by local residents, and a number of community submissions noted that platypus exist throughout the study area. Although the platypus is not listed as a threatened species on either the TSC or the EPBC Act, care should be taken to avoid impacts to this species.

3.2.3 Wildlife Corridors

The DEC has proposed and mapped key habitat and wildlife corridors. These mapped outputs indicate areas of potential high conservation value for priority forest fauna and habitat corridors that link across the landscape. The areas of vegetation form part of a large network of vegetation patches and represent potential linked habitat for species. At the regional scale, there are three major corridor linkages cross the study area. Riparian vegetation is also important for a range of species, providing a movement corridor along watercourses, as well as providing a filtration buffer for runoff into the creeks and rivers.

Byron Shire Council also provides mapping of wildlife corridors in the *Byron Biodiversity Conservation Strategy*. These corridors show a close correlation to the corridors identified by DEC, although they also include additional areas outside the DEC corridors.

The corridors identified by Byron Shire Council and DEC are described below and illustrated in **Figure 3.1**.

- Lying along the St Helena Road ridgeline and then down to the coastal floodplains are two east-west DEC subregional wildlife corridors. The northern corridor links Goonengerry National Park to the northwest with Tyagarah Nature Reserve to the northeast while the southern corridor links Skinners Shoot with St Helena and the Goonengerry-Tyagarah corridor. Cleared areas, patches of Camphor Laurel and the existing Pacific Highway already fragment these corridors.
- Southeast of Bangalow a U-shaped subregional corridor links Newrybar Swamp with Piccadilly Hill. This corridor contains a number of patches of high quality rainforest. However, cleared areas and Broken Head Road heavily fragment these patches.
- South of Tintenbar an east-west DEC regional corridor crosses the study area from Ballina Nature Reserve in the east to Emigrant Creek near Tintenbar in the west and then south to Uralba Nature Reserve. This corridor is highly fragmented by cleared areas and the existing Pacific Highway.
- East of study area are a series of north-south DEC regional corridors. From north to south they link Tyagarah Nature Reserve, Cumbebin Swamp Nature Reserve, Arakwal National Park, Seven Mile Beach and Ballina Nature Reserve, and all the east-west corridors connect with these north south corridors. Although these corridors are better vegetated than the east-west corridors, they are still fragmented by numerous roads, two railway lines, cleared farming land and the townships of Ewingsdale, Bryon Bay, Suffolk Park and Lennox Head.

Ballina Shire Council is presently finalising a Biodiversity Conservation Strategy, which would identify wildlife corridors and patches of vegetation of high conservation value. A wildlife corridor is likely to cross the study area from Ballina Nature Reserve in the east along Sandy Flat Road to Emigrant Creek near Tintenbar in the west, and then north along Emigrant Creek to Killen Falls and Emigrant Creek Dam. The exact location of this corridor has not been finalised, but is likely to be similar to the DEC corridor discussed above.

3.2.4 Terrestrial Ecology Constraints

As discussed, records of threatened species have been compiled from a variety of sources and used to assist in constraints mapping. However, rather than using these records, the presence of suitable habitat for threatened species has been used as an indicator that threatened species may be present and patches of vegetation have been mapped accordingly.

The conservation significance of each vegetation patch within the study area was evaluated based on its suitability as habitat for threatened species, size, connectivity, formal conservation status and ecological integrity. An evaluation based on the suitability of habitat for threatened species, rather than using the records of threatened species themselves, has been used as it results in a more conservative analysis. Patches of vegetation dominated by Camphor Laurel have been upgraded to a higher constraint rating if threatened species are known to occur in these patches.

Vegetation patches were then classified and mapped as being either 'Very high', 'High', 'Medium' or 'Low' constraints, taking into account their conservation significance, any known recordings of threatened species and the level of Camphor Laurel infestation. Terrestrial ecology constraint levels are defined in **Table 3.1** and the location of classified vegetation patches are shown in **Figure 3.1**.

Table 3.1 Terrestrial Ecology Constraints

Constraint Classification	Description
Very high	National Park Estates (i.e. National Parks and Nature Reserves), SEPP 14 Wetlands, and ecological sites listed on the Register of the National Estate (RNE).
High	Any native vegetation mapped by DEC as occurring within a regional or sub-regional wildlife corridor and/or being key habitat.
	Patches of vegetation identified (or preliminary listed) as EEC.
	Large patches of native vegetation and smaller patches that are connected to contiguous native vegetation, as they have high connectivity and/or intrinsic habitat value.
	Any vegetation patches on properties that are participating in the Land for Wildlife program or revegetation programs coordinated by the Big Scrub Rainforest Landcare Group.
	Patches of Camphor Laurel that are known to contain threatened species and occur within a DEC wildlife corridor.
Medium	All other native vegetation.
	Patches of Camphor Laurel that are known to contain threatened species or fall within a DEC wildlife corridor.
Low	Patches of Camphor Laurel or plantations as they have a lesser conservation value than locally endemic native vegetation.

3.3 Aquatic Ecology

This section summarises the existing conditions and constraints identified in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Aquatic Ecology and Water Quality Working Paper* (RTA 2006).

Field investigations of watercourses in the study area were undertaken between December 2004 and May 2005. Assessments were made of water quality, flow and colour and morphological features, and the characteristics of the riparian zone were recorded. Other features such as barriers to fish movement, the extent and type of disturbance of each site, and the observed presence of other fauna were also recorded. Additionally, information from residents regarding aquatic and terrestrial fauna observed in various waterbodies was compiled and considered when assessing the value of aquatic habitats.

In November 2005, fish and mobile macroinvertebrate sampling was carried out in selected creeks and wetlands where the shortlisted route options cross waterways categorised as having fish habitat. Fish and mobile invertebrate presence in waterways is a good indicator of aquatic health. These additional investigations were undertaken after the RODR was finalised. Aquatic ecological conditions presented in this document reflect the updated data.

3.3.1 Aquatic Habitats

The study area contains a number of watercourses with varying grades of fish habitat, referred to as minimal, moderate or major. Sandy Flat Creek, Skinners Creek, Simpson Creek and Tyagarah Creek are waterways with intermittent flow that contain potential refuge, breeding or feeding areas for some aquatic fauna. These waterways contain minimal fish habitat or are unlikely to contain fish habitat.

Newrybar Drain (including Dead Mans Creek and North Creek), Emigrant Creek, Byron Creek and Tinderbox Creek are permanent or intermittent waterways with clearly defined bed and banks, semi-permanent to permanent waters, and the presence of aquatic vegetation or known fish habitat. These waterways contain moderate fish habitat, however fish habitat in Newrybar Drain is limited by maintenance activities that remove snags, accumulations of sediment and aquatic vegetation. In addition, the Newrybar Drain and Emigrant Creek connect to major fish habitats outside the study area. The Newrybar Drain connects to the Newrybar Swamp, while Emigrant Creek Dam is a major fish habitat.

3.3.2 Threatened Species

In addition to a survey of habitats, databases were searched for the possible presence of threatened or endangered aquatic species in the study area. The following species were identified as requiring consideration:

- Eastern freshwater cod (*Maccullochella ikei*).
- Oxleyan pygmy perch (*Nannoperca oxleyana*).
- Olive perchlet (*Ambassis agassizii*).
- Freshwater catfish (*Tandanus tandanus*).

Eastern freshwater cod and oxleyan pygmy perch are identified as threatened species under the *Fisheries Management Act 1994* and are also listed under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999*. The olive perchlet and the freshwater catfish are not listed as threatened species; however these species have been identified as requiring consideration.

The fish and macroinvertebrate sampling did not identify any threatened species, however the freshwater catfish was found at one location in Emigrant Creek. Freshwater catfish is a species requiring consideration because it has shown decline in numbers in its natural habitat of freshwater watercourses.

3.3.3 Constraints

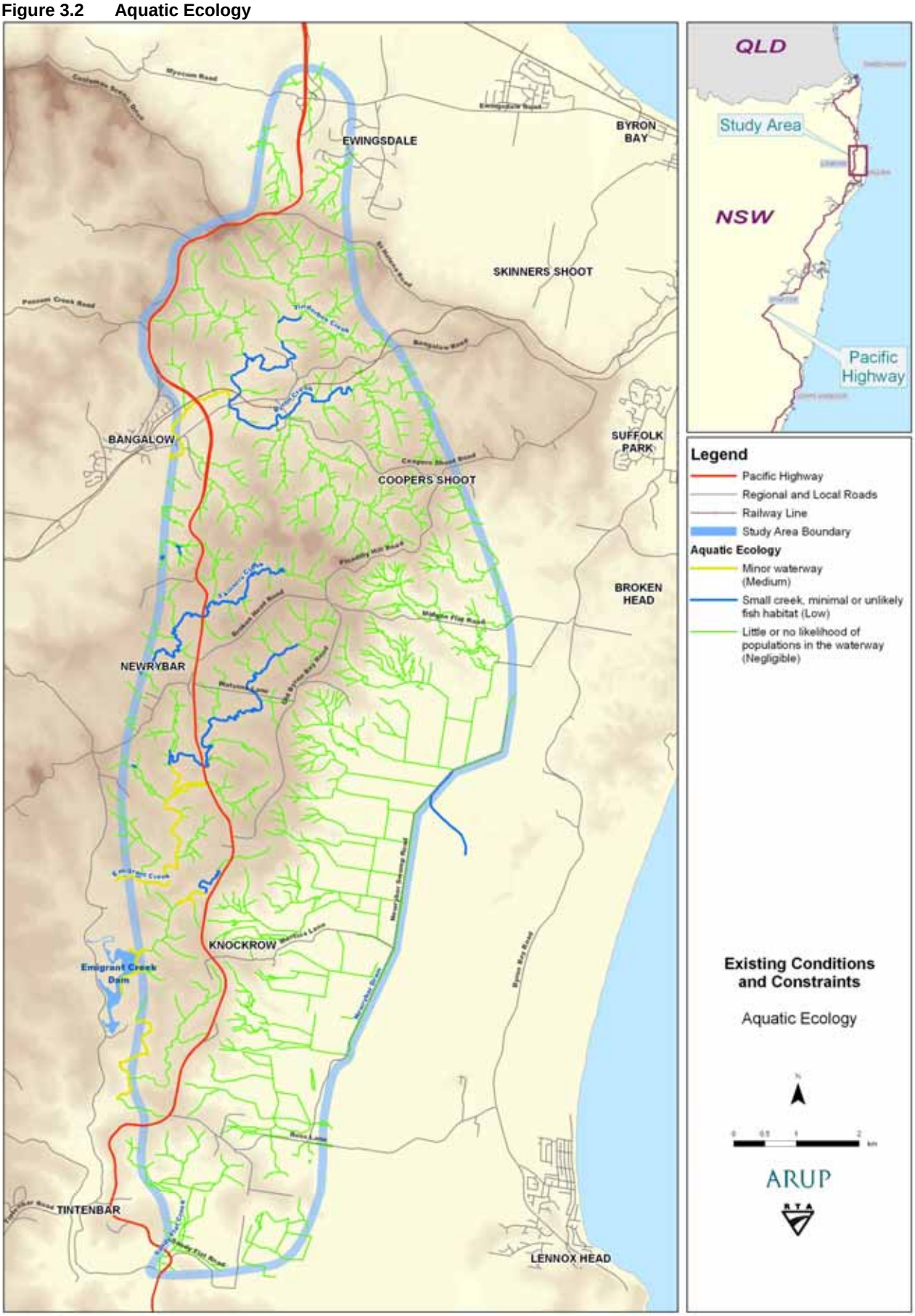
Based on field investigations, waterways in the study area were assigned a constraint classification according to the classifications shown in **Table 3.2** and mapped in **Figure 3.2**. Notably no watercourses have been allocated a 'high' classification. Emigrant Creek and Byron Creek both contain sections that have been classified as 'medium' constraints. These two creeks, as well as Skinners Creek and Tinderbox Creek, also include stretches of 'low' constraint waterway. In addition to these classified waterways, there are a number of waterways that are small ephemeral creeks or drainage lines with minimal or no fish habitat. These waterways are considered to represent negligible aquatic ecological constraints and have been mapped as such in **Figure 3.2**.

It is important to note that the constraints classification for any one watercourse may vary along the length of the waterway, because the waterway's features can change along its length. Further, classification of constraints was considered conservatively. That is, if one part of a stretch of a waterway was classed higher then the rest of that stretch, then the whole stretch were classified at the higher level.

Table 3.2 Watercourse Constraints Classification

Constraints Classification	Definition
High	Permanent or major waterway with clearly defined creek bed and banks, considered moderate or major fish habitat. Potential for alteration to minimal fish habitat, fish passage, fish abundance, diversity or water quality that can be at least partially mitigated at design and construction phases. Potential for presence of threatened species, or threatened species known to be present. High level of recreational and/or commercial fishing activities occur in the waterway that may be affected. Waterway located close to a drinking water storage or large supply to drinking water storage.
Medium	Minor waterway that connects with wetlands and provides potential refuge, breeding or feeding area for aquatic fauna. Potential for minor alteration to minimal fish habitat, fish passage, fish abundance, diversity or water quality that can be effectively mitigated at design and construction phases. Potential for presence of threatened species. Some recreational and commercial activities occur in the waterway and require consideration. Waterway located a moderate distance away from drinking water storage or large supply to drinking water storage.
Low	Small creek with minimal or unlikely fish habitat, may be ephemeral. Could be crossed without in-stream structures or impacts on creek banks with no or negligible effects on fish habitat, fish passage, fish abundance, diversity or water quality. Little or no likelihood of threatened aquatic species or populations in the waterway. Little or no recreational or commercial fishing activities that would be affected by a waterway crossing. Waterway located a substantial distance away from drinking water storage or large supply to drinking water storage.

Figure 3.2 Aquatic Ecology



3.4 Water Quality

This section summarises the existing conditions and constraints identified in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Aquatic Ecology and Water Quality Working Paper* (RTA 2006).

Previous water quality sampling has been undertaken at Tinderbox Creek and Emigrant Creek by WBM (1999) and Sinclair Knight Merz (SKM) (2005). The results of sampling at Tinderbox Creek indicate that dissolved oxygen, pH and salinity were within Australian and New Zealand Environment Conservation Council (ANZECC) levels, however the SKM studies (which also analysed for nutrients, chlorophyll and microbiological pollutants) indicate that the current land uses, particularly agriculture, have had deleterious impacts on water quality in the Emigrant Creek catchment. Given that land uses are similar throughout the study area, similar results could be expected for the watercourses in nearby catchments.

Physical-chemical properties (conductivity, salinity, temperature, turbidity, dissolved oxygen, pH, and oxidation reduction potential) were recorded during site inspections between 30 November 2004 and 26 May 2005. Water samples were collected and analytically tested for organochlorine pesticides, trace elements, oil and grease, nitrogen, phosphorus and chloride and compared against the relevant ANZECC trigger value. Water quality testing was undertaken at Emigrant Creek, Byron Creek, Skinners Creek, Sandy Flat Creek, and at two locations on North Creek (on the slopes and on the plain).

The results of this testing are:

- pH is generally below the guideline value except for Byron Creek where it is within the guideline range. North Creek showed variable results.
- Salinity is within the guidelines for Emigrant Creek and Byron Creek, and below the guidelines for Skinners Creek. North Creek again showed variable results.
- Turbidity, organochlorine and heavy metals are within the guideline values for each of the creeks, except for copper which showed variable results for Emigrant Creek.
- Total phosphorous and nitrogen is above the guidelines for each of the creeks, except for North Creek, which again showed variable results.
- There are no guideline values for oils and greases, sulfate and suspended solids. There were no oils and greases found in any of the water samples taken.

These water quality results are considered typical of aquatic ecosystems that, historically, have been highly disturbed by agricultural and grazing practices.

3.4.1 Drinking Water Catchments

Parts of the study area lie within two catchment areas for drinking water, namely the Emigrant Creek Dam Catchment and the proposed Lismore Source Water Catchment (which includes Tinderbox, Byron and Skinners Creeks and their respective catchments). The area of each catchment is shown in **Figure 3.20.**

3.4.2 Water Quality Constraints

The construction of roads can potentially impact on the water quality, sediment quality and biota of waterways by introducing sediment and contaminants. As such, the position of Emigrant Creek Dam (which is outside of the study area) and the associated drinking water catchment will need to be considered during construction. The length of the proposed highway within the drinking water catchment and the proximity of the highway to Emigrant Creek and to Emigrant Creek Dam have been added as evaluation criteria for assessing the impacts of the short list of route options (see **Appendix B**).

Waterways have been classified as ‘high’, ‘medium’ or 'low’ based on a range of the waterway’s characteristics. These characteristics include proximity to drinking water storage, whether it supplies drinking water, and the current use of the waterway. Classifications for waterways are included in **Table 3.2**.

3.5 Cultural Heritage

This section summarises the existing conditions and constraints identified in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Cultural Heritage Working Paper* (RTA 2006).

Since the RODR, additional Aboriginal archaeological and Non-Aboriginal heritage surveys were conducted. These surveys responded to community submissions providing information regarding potential heritage sites. The additional surveys focused on sites that were likely to represent ‘high’ or ‘medium’ heritage constraints and sites that would be potentially affected by the shortlisted route options. (It was not feasible to investigate every potential heritage site identified in community submissions within the study area).

3.5.1 Legislative Context and Methodology

The *National Parks and Wildlife Act 1974* (NPW Act) provides the primary basis for the legal protection and management of Aboriginal sites within NSW. The *Heritage Act 1977* provides the primary basis for the legal protection and management of non-Aboriginal heritage sites within NSW.

The methodology employed for the cultural assessment included review of existing documentation and databases, consultation with the community and local Aboriginal groups and implementation of a survey strategy to assess sites with potential heritage and/or archaeological significance.

Further details of the legislative context for the cultural heritage assessment and the methodologies employed are described in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Cultural Heritage Working Paper* (RTA 2006).

3.5.2 Constraints Classification

Aboriginal archaeological sites have been assessed for archaeological significance and classified as being of local, regional and national levels of importance. These levels of importance relate to ‘low’, ‘medium’ and ‘high’ constraints respectively, as shown in **Table 3.3**.

The cultural importance of an Aboriginal site can only be assessed by the relevant Aboriginal community, and is likely to be more important to the local Aboriginal community than any other. As such, a site that may have low scientific research potential may however have very high cultural significance to the local Aboriginal community.

In addition, the importance of the cultural landscape has been identified by Aboriginal representatives. Assessment of this concept is difficult as any road upgrade will affect the landscape of the study area; however, it is important to acknowledge that the landscape has been highly altered by Europeans. Feedback with the Aboriginal groups is crucial to obtaining this assessment and consultation is ongoing.

Non-Aboriginal heritage sites have been assessed against the State Heritage Register that establishes criteria for listing a site as either local or State significance. The criteria are based on the importance of the site in the context of the social, cultural or natural history of the local area or the State respectively. In addition the broader heritage significance level of a Non-Aboriginal heritage site has been taken into account when classifying it as a constraint.

Constraints classifications are defined in **Table 3.3**.

Table 3.3 Heritage Constraints Classification

Constraint Classification	Description
High	Cultural heritage features of national significance.
Medium	Cultural heritage features of state and regional significance.
Low	Cultural heritage features of local significance.

3.5.3 Existing Aboriginal Sites

Almost the entire area has been subject to total clearance of native vegetation to facilitate farming activities. There are also many examples of ground disturbance in the form of contour banks, irrigation and rock removal that have caused considerable ground disturbance. Rock removal in particular may have had a significant impact on any archaeological sites that may be present.

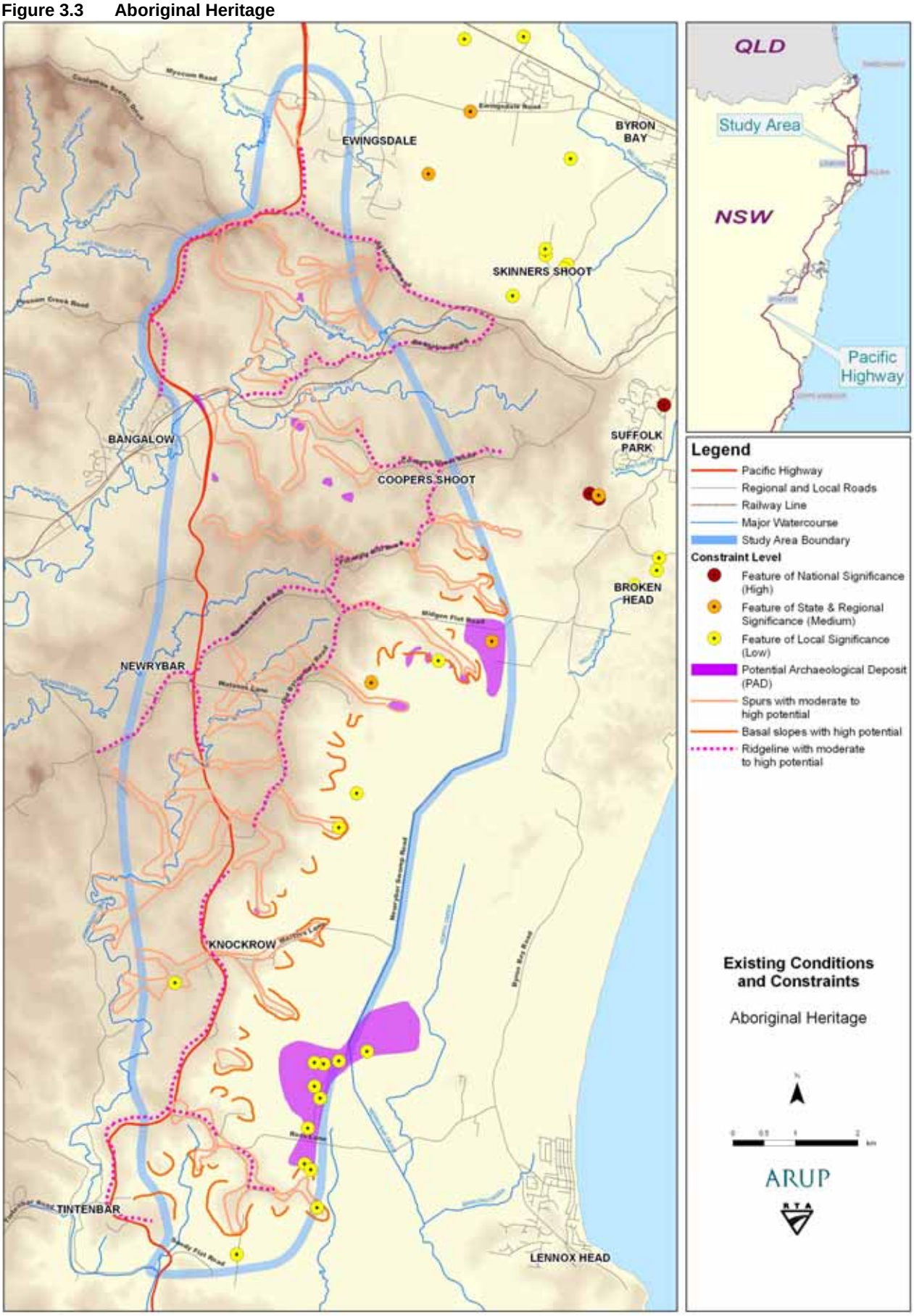
Sixteen Aboriginal sites have been identified in the study area, including nine previously recorded sites and seven sites identified during the field surveys. These sites are illustrated in **Figure 3.3**. The previously recorded Aboriginal sites are identified as artefact scatters that have either been destroyed or the current status was unable to be determined.

The Aboriginal sites identified during the field surveys included five artefact scatters and two isolated artefacts. The archaeological significance of these sites was assessed as low with the following two exceptions:

- Site T2EA5 – The rarity of the artefact types, being two grinding stones located on a flat bench, and the potential for further research makes the archaeological significance of this moderate.
- Site T2EA7 - The occurrence of five stone axes from the same locality with the other artefacts is unusual, and the research value of the site may be higher than for other similar surface scatters. The significance of the site is therefore rated as moderate.

Aboriginal heritage sites and their constraint classification are illustrated in **Figure 3.3.**

Figure 3.3 Aboriginal Heritage



Potential Archaeological Deposits (PADs)

The field surveys were sometimes restricted by ground surface visibility constraints and in order to offset these difficulties areas of PAD have been identified. These areas may not have any surface evidence of cultural activity, but based on models and environmental considerations, are deemed to have potential for sites to exist (usually artefact scatters). Such locations need to be considered in the planning and route selection process but they cannot have any significance assigned to them until they are confirmed or rejected as sites.

Based on micro topographic features identified in the field, thirteen locations within the surveyed properties were identified as having archaeological potential (see **Figure 3.3**). The PADs include elevated terraces above creeklines and the crests of prominent spurs that could have been used as access routes from the high ridges to the creeks. Other PADs include microtopographic features such as basal slopes of spurs that were elevated above the former Newrybar Swamp or other permanent water.

Native Title Claims and Aboriginal-owned Land

A Native Title Claim exists north of Newrybar, from the coast inland, and includes the northern part of the study area. The National Native Title Tribunal has determined that there is a *prima facie* case for the establishment of some rights and interests, including the right to occupy, use and make decisions about the use and enjoyment of the area (non-exclusive), and the right to protect and maintain places of importance and to speak for the determination of the area. The claim, registered in 2003, is now in mediation and has not been granted to date. It should be noted that not all of the land in the claim is subject to claim or claimable. The application does not include freehold land and areas where native title has been extinguished such as roads, public works or certain leases.

3.5.4 Non-Aboriginal Heritage Sites

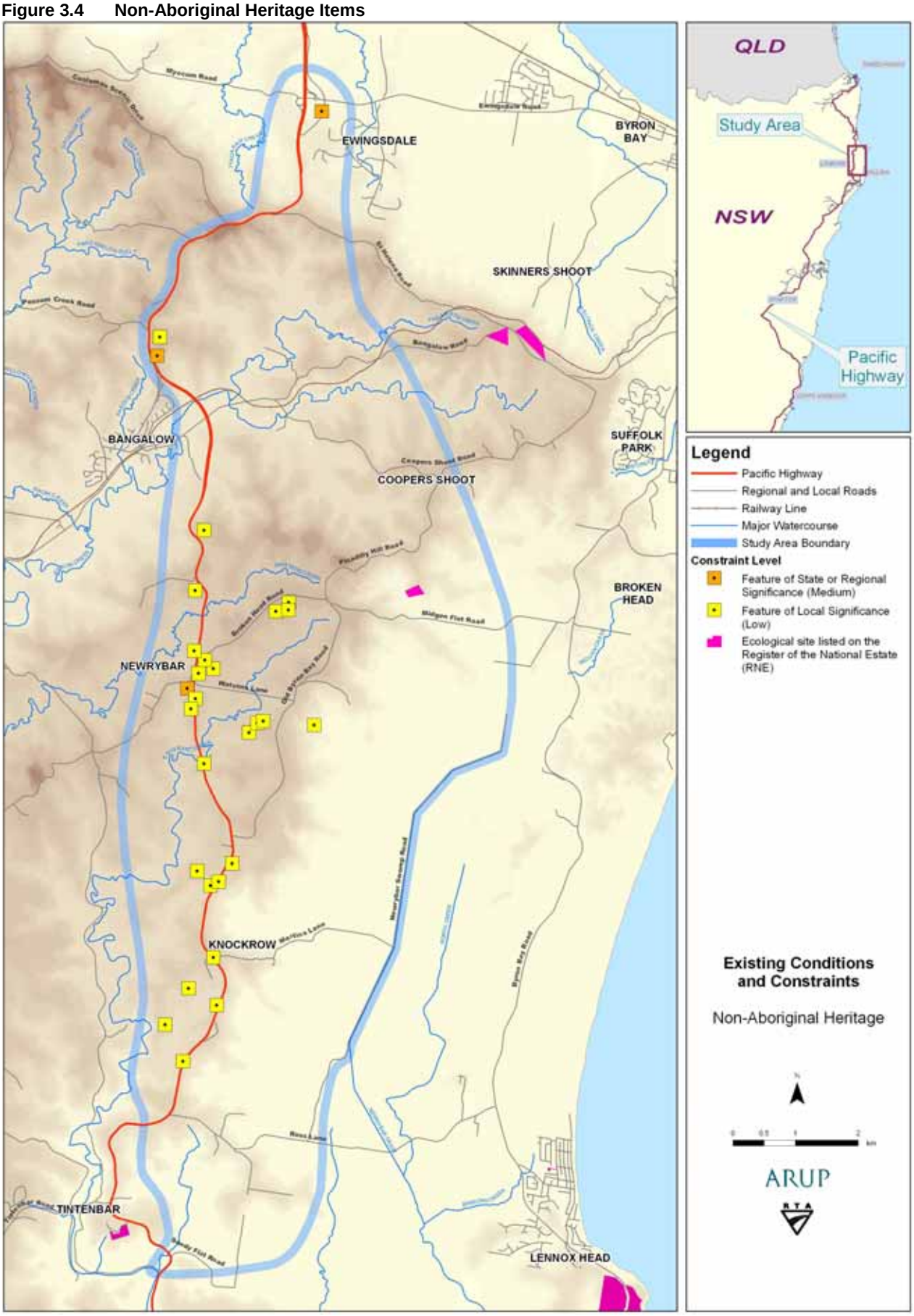
Non-Aboriginal heritage constraints identified by the literature review, through surveys and through consultation with the community are listed in **Table 3.4**, and graphically represented in **Figure 3.4**.

Table 3.4 Non-Aboriginal Heritage Constraints

No.	Name/Type	Location	Heritage Significance	Constraint Classification
T2E H1	Ewingsdale Anglican Church and Community Hall, Relics	Approximately 250 m east of Pacific Highway and 175 m south of Ewingsdale Road.	High (Fulfils criteria for local listing)	Medium (Regional significance)
T2E H2	Jelbon Leigh, Heritage Listed (Byron LEP 1988 and NSW State Heritage Inventory)	Approximately 1 km north of Bangalow and 150 m east of Pacific Highway (Lot 2 DP 719871)	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H3	Bangalow Cemetery, Relic	Approx. 750 m north of Bangalow, east of Pacific Highway	High (Fulfils criteria for local listing)	Medium (Regional significance)
T2E H4	Village of Newrybar, Relics	Approximately 4 km south of Bangalow and 150 m west of Pacific Highway.	High (Fulfils criteria for local listing)	Medium (Regional significance)
T2E H5	Three Fig Trees on The Orchard, Relics (nominated for Byron LEP 1988)	Approx. 200 m west of Old Byron Bay Road and 500 m south of Watsons Lane	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H6	Monument, Relic	Southeast corner of Martins Lane East and Pacific Highway	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H7	Dry Stone Wall	Eastern boundary of property, 242 Old Byron Bay Road	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H8	Possible Grave	'Bonnie Doon', Lawlers Lane, Pacific Highway, Bangalow	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H9	Cricket Pitch and ground	73 Watsons Lane	Moderate (Fulfils criteria for local listing)	Low (Local significance)
T2E H10	Remnant Dry Stone Wall	Common boundary of 186 Broken Head Road and 'Wild Goose Chase' Lot 14 DP578902	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H11	Remnant Dry Stone Wall	South-western boundary of property, 'Wild Goose Chase', Broken Head Road, Lot 14 DP578902	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H12	Remnant Dry Stone Wall	South-eastern section of property, 'Wild Goose Chase', Broken Head Road, Lot 14 DP578902	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H13	1930s Cottage and Fig trees	Pacific Hwy 1.5 km south of Bangalow, 2.5 km north of Newrybar	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H14	Macadamia Castle	Pacific Hwy	High (Fulfils criteria for local listing)	Low (Local significance)

No.	Name/Type	Location	Heritage Significance	Constraint Classification
T2E H15	Fig Tree	Deenford Plantation	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H16	Newrybar School	Broken Head Rd, Newrybar	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H17	House and Fig trees	Martins Lane west	Medium (Trees fulfil criteria for Local listing)	Low (Local significance)
T2E H18	Former Knockrow Schoolhouse	Pacific Hwy, Knockrow	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H19	Former Newrybar Church	Pacific Hwy, Newrybar Village	High (Fulfils criteria for local listing)	Low (Local significance)
T2E H20	c.1900 Farmstead	Pacific Hwy, Newrybar	Moderate (Fulfils criteria for local listing)	Low (Local significance)
T2E H21	1900's homesteads	Pacific Hwy, Knockrow	Low	Low (Local significance)
T2E H22	Homestead	Pacific Hwy, Newrybar	Moderate (Fulfils criteria for local listing)	Low (Local significance)
T2E H23	Early cottage	Pacific Hwy, Knockrow	Moderate (Fulfils criteria for local listing)	Low (Local significance)
T2E H24	Early cottage	Pacific Hwy, Knockrow	Moderate (Fulfils criteria for local listing)	Low (Local significance)
T2E H25	Early cottage	Pacific Hwy, Knockrow	Moderate (Fulfils criteria for local listing)	Low (Local significance)
T2E H26	Early cottage	Pacific Hwy, Newrybar	Moderate (Fulfils criteria for local listing)	Low (Local significance)
T2E H27	Early cottage	Pacific Hwy, Newrybar	Moderate (Fulfils criteria for local listing)	Low (Local significance)

Figure 3.4 Non-Aboriginal Heritage Items



3.6 Air Quality

This section summarises the existing conditions and constraints identified in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Air Quality Working Paper* (RTA 2006).

3.6.1 Climate and Meteorology

The climate of the study area is heavily influenced by offshore meteorological activity. The study area has a warm to subtropical climate and high rainfall, which provides an ideal situation for a great variety of agricultural and horticultural pursuits.

Table 3.5 lists climatic data recorded at Byron Bay weather station between 1948 and 2004.

A map of fog prone areas, in the study area, has been compiled from local community observations, and is presented in **Figure 3.5**. This map shows that areas of land at lower elevations and confined in valleys are prone to fog formation. To the east of the escarpment, fog is likely to occur up to an elevation of 30 m above sea level, while on the plateau to the west of the escarpment, fog is likely to occur adjacent to streams and in valleys.

Community observations indicate that fog frequency in the study area is higher than indicated by the observations recorded at Alstonville, NSW (west of Ballina). The Alstonville area may experience fewer fogs as it is at a slightly higher elevation than the parts of the study area that were identified as being prone to fogs. However, the higher frequency of fogs reported by the community may also be because there has been no strict distinction made between fogs and mists.

3.6.2 Dispersion Characteristics

The dispersion characteristics of the area are affected by wind speed, wind direction, atmospheric stability class and mixing height. Meteorological data was obtained from the Bureau of Meteorology recorded at the Ballina Airport automated weather station from December 2003 to November 2004. Cloud cover data is recorded at the Byron Bay Lighthouse.

On an annual basis the data indicates that winds are predominantly from the north and west. This correlates with the surrounding terrain, particularly the escarpment to the northwest and large areas of low-lying terrain to the north, south and west of the Ballina airport. In spring and summer the wind is mainly from the north, while in autumn and winter the wind is predominantly from the west. The annual average wind speed over the period was 3.9 metres per second.

Meteorological conditions to the east of the escarpment are likely to be similar to that of Ballina Airport, particularly the high proportion on northerly winds channelled by the escarpment. Meteorological conditions on the plateau above the escarpment are likely to differ from those experienced at Ballina due to greater exposure and different drainage patterns.

Atmospheric Stability is usually assigned according to six classes. These classes range from Class A which relates to unstable conditions in which plumes would spread rapidly, while Class F relates to stable conditions, in which a plume would spread slowly. Classes B to E relate to intermediate dispersion conditions. The frequency of occurrence of each the different stability class was identified by data from the Byron Bay lighthouse. The high frequency of intermediate class stabilities (predominantly D Class stability for 38.6% of the time) indicates that atmospheric conditions would favour relatively quick dispersion for a significant proportion of the time.

Figure 3.5 Fog Prone Areas Within the Study Area

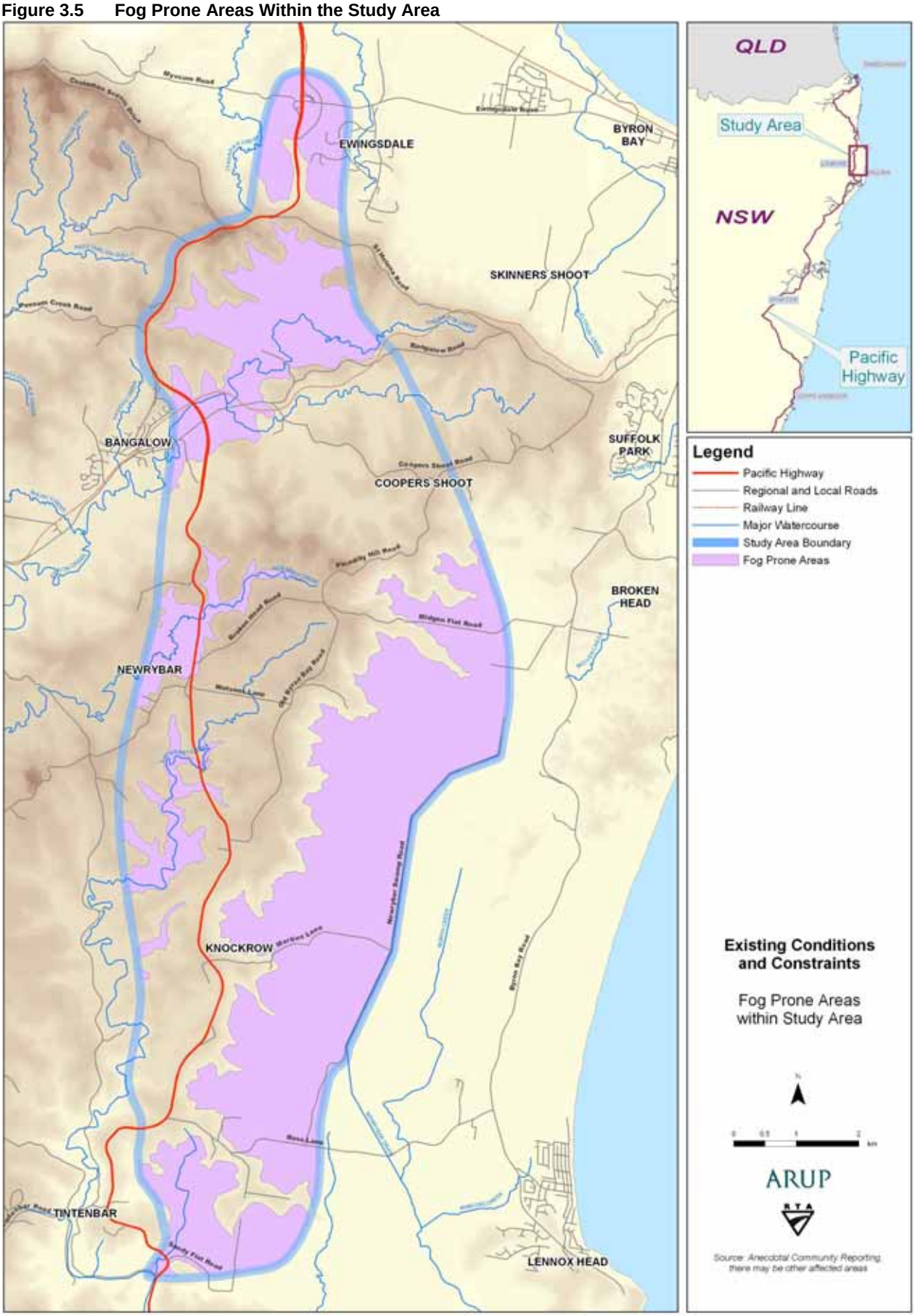


Table 3.5 Climate Data, Byron Bay (Bureau of Meteorology, 2004)

	Description
Temperature	The annual average maximum and minimum temperatures experienced are 23.7°C and 16.5°C respectively. On average January and February are the hottest months with an average maximum temperature of 27.5°C. July is the coldest month, with average minimum temperature of 11.7°C. Average minimum and maximum temperatures during summer range between 19.5°C and 27.5°C. Average minimum and maximum temperatures during winter range between 11.7°C and 20.3°C.
Humidity	The annual average humidity reading is 76% at 9am and 71% at 3pm. The annual average humidity is 71%. The month with the highest humidity on average is February with a 9am average of 83%. The month with the lowest humidity on average is August with a 3pm average of 64%.
Rainfall	Rainfall data shows that March is the wettest month, with an average rainfall of 212.1 mm over 17 days. The average annual rainfall is 1707.6 mm with an average of 153 rain days. There is a seasonal variation in average monthly rainfall, with most rain falling in autumn and the least rain falling in spring. The number of rain days is also highest in autumn and lowest at the end of winter and in spring.

3.6.3 Air Pollutants from Traffic

Air pollutants emitted from traffic include:

- Carbon dioxide (CO_2).
- Carbon monoxide (CO).
- Nitrogen oxides (NO_X) comprising mainly a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2).
- Particulate matter with an aerodynamic diameter less than 10 microns (PM_{10}) and less than 2.5 microns ($PM_{2.5}$).
- Hydrocarbons including benzene, xylene, toluene, 1,3-butadiene, polycyclic aromatic hydrocarbons (PAHs), and odours.

Diesel engines are a major contributor to air pollution and while heavy duty diesel vehicles make up less than 10% of the total Australian fleet and approximately 13% of vehicle kilometres travelled, they contribute approximately 40% of oxides of nitrogen and 60 to 80% of the particulate emissions by the road transport sector.

3.6.4 Existing Air Quality

There is limited information regarding existing air quality within the study area. Areas located away from larger regional centres generally do not have air quality monitoring stations. The main reason for this is that in predominantly rural areas, pollutants do not exist in high enough concentrations to cause adverse environmental or health impacts or concerns. As such, monitoring for such pollutants on a long term basis is not usually undertaken outside metropolitan and/or industrial areas.

Air quality monitoring data has, however, been collected by the RTA at the Pacific Highway near Coffs Harbour. The monitoring site was located north of Coffs Harbour, in close proximity to the highway, and as such the concentrations of pollutants include traffic emissions and are therefore likely to be higher than background levels in the study area. The data therefore gives a conservative indication of the air quality that would be experienced on the north coast of NSW.

The RTA monitoring data includes the concentrations of pollutants, CO, oxides of nitrogen (NO_x, NO, NO_2), and $PM_{10,}$ and meteorological data between October 2005 and January 2006. The maximum 1-hour and 8-hour average CO concentrations were 1.2 mg/m^3 and 0.3 mg/ m^3 respectively. The maximum 1-hour average NO_2 concentration was 73.8 μg/ m^3, while the maximum 24-hour average PM_{10} concentration was 37.8 μg/ m^3.

In all cases the maximum concentration recorded were well below the relevant DEC air quality criteria.

3.6.5 Air Quality Goals

Air quality goals are set by regulatory authorities to protect the community from exposure to pollutants in concentrations that cause health impacts. Goals, standards and limits aim to protect the most sensitive members of the community, including children (at home and school).

The DEC has air quality goals for nitrogen dioxide, carbon monoxide and particulate matter. **Table 3.6** lists the relevant DEC air quality goals for NSW. These goals are used for assessing roadway projects and impose a constraint on the location and design of a highway. In general, routes which have shorter sections of steep grade will have lower overall emissions. Furthermore, impact on health will also depend on whether there are receptors close to the sections that have a steep grade and the prevailing meteorological and climatic conditions. Whatever the roadway configuration, the pollution levels must not exceed the air quality criteria set out by the DEC at sensitive receptors.

Table 3.6 DEC Air Quality Goals

Pollutant	Goal	Averaging period
Carbon monoxide (CO)	25 ppm or 30 mg/m³ 9 ppm or 10 mg/m³	1-hour 8-hour
Nitrogen dioxide (NO2)	0.12 ppm or 246 μg/m³ 0.03 ppm or 62 μg/m³	1-hour Annual
Particulate matter < 10 microns (PM10)	50 μg/m³ 30 μg/m³	24-hour Annual

Planning and Socio-Economic Characteristics

This section addresses planning and land use, specifically agricultural land use, as well as social and economic, noise and visual and landscape characteristics. Noise and visual characteristics are included in this section as their impacts relate to lifestyle and amenity considerations addressed as socio-economic impacts.

3.7 Planning and Land Use

3.7.1 Updated Land Use Mapping and Comparative Assessment of Agricultural Impacts

Due to the significance of agricultural land in the study area, additional detailed investigations were conducted on current land use practices on agricultural lands that are potentially affected by the short list of route options. These investigations form the basis of the comparative assessment of the relative worth of potentially impacted land and are based on:

- May 2005 orthorectified aerial photography.
- Responses from surveys of potentially affected landowners.
- Field truthing conducted in December 2005.

Land use derived from these sources is mapped in **Figure 3.6.** The new mapping focuses on the areas potentially affected by the short list of route options and supersedes the land use information presented in the RODR.

The detailed information on land use by area and by lot is combined with land worth and agricultural improvement worth in the comparative assessment of impacts for each route option (see **Section 3.7.4**). Details of the agricultural investigations are included in *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Working Paper on Agricultural Considerations for Route Options* (RTA 2006).

3.7.2 Statutory Land Use Planning

There are a number of statutory planning instruments that would apply to the proposed upgrade. These are discussed in **Section 1.5**.

Roads are not prohibited in any of the Byron or Ballina LEP zones in the study area.

3.7.3 Townships, Villages and Residential

Within or adjacent to the study area, the main urban settlements are Bangalow and Newrybar, Knockrow and the Ewingsdale residential area.

- Bangalow – The built-up area of Bangalow is located on the western boundary of the study area. The existing Pacific Highway was diverted away from the main street of Bangalow in 1997 to the current alignment about 1 km east of the township. The bypass has created new business opportunities for the village, enhanced its sense of place, community and historical values. Bangalow has a population of approximately 1,200 people, serves as a local service and community centre for the northern part of the study area and surrounding rural areas, and has a range of local community facilities and services including Primary School, Community Health Centre, Community Children's Centre and a police station. Discussions with local council and real estate agents have noted that there are limited existing residential opportunities within the township, and that one of the new residential areas to the west of the town is bordered by the current Pacific Highway bypass.
- Newrybar – The village centre of Newrybar which includes houses, general store, café, hall, nursery, and an agriculture supply store, is located immediately to the west of, but not directly fronting, the existing Pacific Highway. The Newrybar Primary School is located to the east of the highway on Broken Head Road. There are 600 people in the local postcode for Newrybar, of

which 110 live along Broken Head Road, and there is a strong linkage of the local community and businesses along Broken Head Road.

- Knockrow – Knockrow contains a number of settlement areas, as well as Macadamia Castle, which are generally connected to, or surrounded by agricultural land dominated by grazing and horticulture.
- Ewingsdale – The residential community of Ewingsdale is located at the northern end of the study area 6 km inland from Byron Bay, surrounded by farmland to the east, the escarpment to the south, the existing highway to the west and Ewingsdale Road to the north. Ewingsdale has a community hall and church, and a Steiner School.

In addition to existing residential or urban centres, Ballina Shire Council has specified the southern part of the study area as a Rural (Urban Investigation) Zone in its LEP, and both Ballina Shire Council and Byron Shire Council are currently undertaking investigations within the study area as part of planning activities for future urban areas. The Ballina Council's Cumbalum Structure Plan provides the framework for Council's consideration of future rezoning requests within the broader Rural (Urban Investigation) Zone and will broadly identify the distribution of neighbourhoods, open spaces, commercial facilities and identify the infrastructure needs of the area.

In the Byron Rural Settlement Strategy, Byron Shire Council has identified an area known as Natural Lane for future rural residential development. This area is located to the north of Midgen Flat Road and below the escarpment in the vicinity of Granny Waterhouse Drive.

There are also contiguous settlement areas across the study area that have created neighbourhoods beyond the townships and villages. Existing centres, areas under investigation for potential future urban land uses, and the location of rural residential clusters or contiguous settlement areas are illustrated in **Figure 3.7**.

3.7.4 Agriculture and Rural Land Uses

The most extensive agricultural land uses in the study area (in terms of land occupied) are beef cattle grazing, sugar cane and horticulture (including tree crops, such as macadamias, coffee and stone fruits) (see **Figure 3.6**).

As noted in **Section 3.7.1** due to the importance of agricultural activities within the study area, additional detailed agricultural land use investigations were carried out. In assessing the impact on agriculture, it was assumed that the market price for land is a reflection of the present value of all expected future benefits from the investment; and that pre-construction conditions for drainage, water supply, access, and services would be restored to each residual property. Agricultural impacts were disaggregated into those that affect the land and those that affect the agricultural improvements on the land.

For each lot affected by the shortlisted route options, both the area directly affected by the footprint of the route option and the residual area within the lot was measured. For the severed portions of lots, the degree of affectation (which relates to the severed portion and the land use) was determined for each land use and used to calculate the worth of the agricultural impact. The estimated agricultural impacts of the shortlisted route options are summarised in **Table 3.7**.

Table 3.7 Worth of Potentially Impacted Agricultural Lands ($ million)

Description	Option A	Option B	Option C	Option D
Direct impact (excluding rural residential)	$5.2	$5.9	$3.9	$3.9
Indirect impact (severance)	$2.7	$3.2	$1.6	$1.0
Impact on farm buildings (including house blocks, but excluding rural residential)	$7.9	$7.4	$4.9	$2.8
Total	$15.8	$16.5	$10.3	$7.7

There is one contiguous area that has been designated as State Significant Farmland under the Northern Rivers Farmland Protection Project (see **Figure 3.7**). This is located to the north of Skinners Creek between Piccadilly Hill Road and the existing Pacific Highway. The majority of the rest of the study area (excluding the escarpment, and committed urban or residential areas) is categorised as Regionally Significant Farmland.

3.7.5 Land Use Constraints

The land use constraints, as defined in the RODR, are listed in **Table 3.8**. Locations of 'very high' and 'high' constraints land use areas are shown in **Figure 3.7**.

Table 3.8 Land Use Constraints

Constraints Classification	Description
Very high	Townships and associated infrastructure. Includes Bangalow, Ewingsdale and the village centre of Newrybar and the Newrybar School.
High	Settlement areas including those located on St Helena Road, Tinderbox Road, Coopers Shoot Road, Piccadilly Hill Road, Broken Head Road, Hambly Lane area, Old Byron Bay Road, Ivy Lane, Martins Lane, Martins Lane East, Carney Place and the Ross Lane area.
	Areas designated for future residential development as identified in Ballina and Byron LEPs and/or relevant Shire Strategies, including Natural Lane in Byron Shire and the Cumbalum Ridge in Ballina Shire.
	State Significant Land as identified in DoP's Farmland Protection Project.
Medium	Agriculture production enterprises, other business and rural residential properties.

Figure 3.6 Agricultural Land Use Map (Data shown for area of shortlisted route options only)

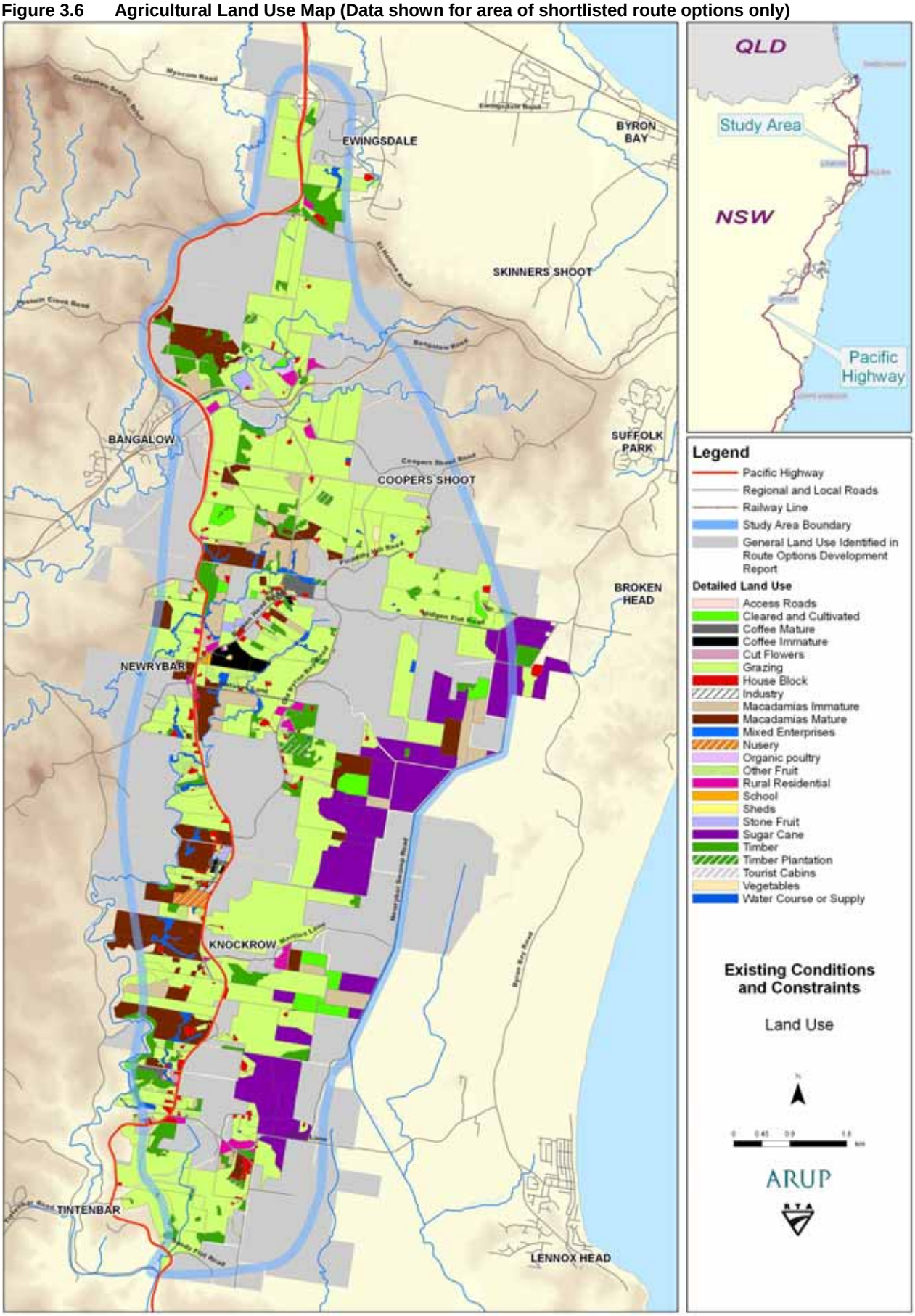
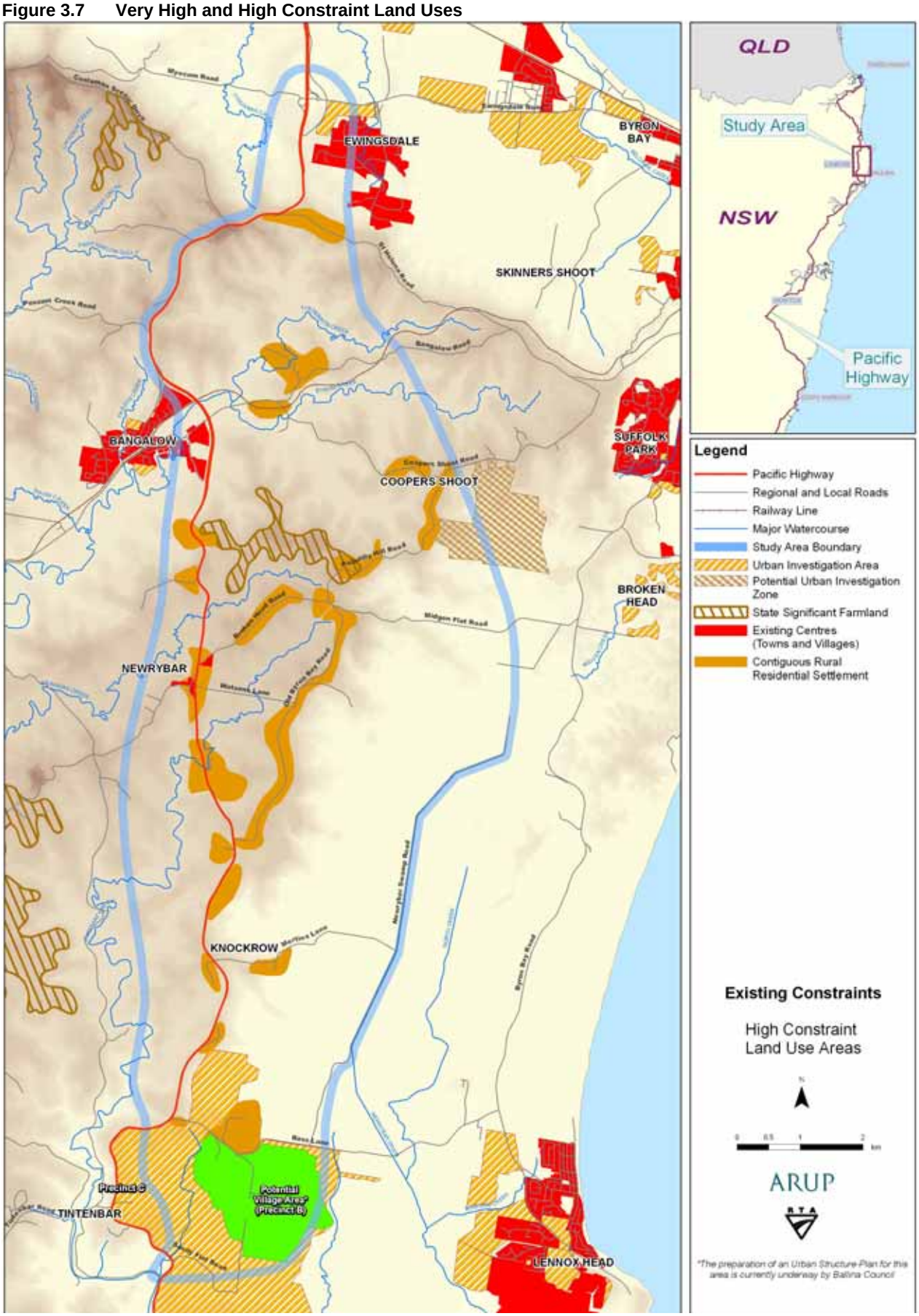


Figure 3.7 Very High and High Constraint Land Uses



3.8 Local and Regional Economy

Economic analysis has been undertaken at both the local and regional level to ascertain the reliance of the economy on certain business activities and to allow differentiation of the shortlisted route options based on affects to key economic indicators.

The assessment of the impacts to the regional economy is based on potential changes in agricultural land use as described in *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Woking Paper on Regional Economic Impacts of Changes in Agricultural Land Uses* (RTA 2006). The potential impacts to the local economy were investigated by qualitatively examining the effects of the highway upgrade to businesses within the study area as detailed in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Land Use, Planning and Socio-Economic Working Paper* (RTA 2006).

3.8.1 Economy of the Study Area and the Region

Tourism

Tourism is a vital part of the economy of the region. This importance is reflected in the number of residents employed in the Accommodation, Cafes and Restaurants sector which amounts to 7% of the regional population, compared to 5% for NSW. Within the region, Byron Shire has the highest proportion of people employed in this sector (11%). Industries such as Retail Trade may also have some dependence on tourism in the area (Northern Rivers Regional Development Board 2003).

Agriculture

Eight percent (8%) of residents in the region are employed in agriculture, fishing and forestry; and agriculture provides the third largest source of income in Byron Shire. Agricultural enterprises in the Northern Rivers region include:

- Beef cattle production, which is the greatest land use and the Northern Rivers region's biggest single income earner ($140 million annually, DPI 2000).
- Bananas, dairying, vegetables and sugar cane, which generally have been established for many years. There is decline or consolidation and change in focus in some of these industries such as a change in the variety of bananas grown.
- Macadamias that are now well established.
- Low chill stonefruits that have been grown commercially for 20 years.
- New and emerging industries such as coffee, native foods and herbs (culinary and medicinal).
- Organic production which also continues to be established across the range of enterprises.

Local agri-business owners suggest that the area of highly productive land between Newrybar, Lismore and Ewingsdale is known as a 'Food Bowl'. The local businesses are also seeking to establish a regional brand and are trying to establish the area as a 'clean green area', with minimal use of pesticides and herbicides in production.

Business Areas

The key business areas within the study area are discussed below.

Bangalow – Since the Bangalow Bypass was completed the town has undergone considerable change, resulting in a quiet township and destination for visitors drawn to its range of cafes, boutique stores, antique stores, gift and souvenir shops. The upgraded highway to the north has also made the trip from southeast Queensland achievable in two hours bringing a considerable amount of Queensland day-trippers. There are some 186 businesses listed in Bangalow, of which eight are likely to have linkages to highway traffic, including the service station, café, hotel, patisserie, gift shops and tourist accommodation facilities. There are currently no commercial vacancies in Bangalow and reduced scope for future development due to Council planning restrictions on where commercial development could be carried out.

Newrybar – The business areas linked to Newrybar can be conceptually separated into two distinct areas. The first area to the west of the existing highway is the village centre, the second, is along the Broken Head Road running past the school to the east of the existing highway. There are four established businesses in Newrybar, the Harvest Café, General Store, Newrybar produce and a local nursery. The Harvest Café and General Store are likely to have trade linked to local highway based traffic and have the potential to be affected by the proposed highway upgrading.

Current business growth in Newrybar is strong with two recently opened businesses, as well as two businesses that have been approved for future development. Businesses along Broken Head Road have an agricultural focus and as such are linked closely to the local production of coffee and other produce including small retail outlets and farm gate stalls. Local business owners have stated that the potential expansion of small retail businesses and cafés is strongly associated with the ability to maintain the visual amenity of the surrounding area. A local processor of coffee has stated that the loss of prime coffee production land has the potential to effect future export orders in the short term through disrupted supply and potential loss of the clean green image.

Knockrow – Macadamia Castle is the primary business located at Knockrow and includes a café, retail outlet (souvenirs and outlet for local produce), playground, animal park and mini-golf park. It is used not only by passers by but also serves a meeting point and a function centre for locals. The Macadamia Castle has up to 30 employees, with up to 80% of its trade highway related, and provides access for local producers to the passing tourist trade. Anecdotal evidence from local business owners suggests that there has been steady growth of the Macadamia Castle over the last few years.

Economic Growth

The natural amenity experienced in the study area is a major attraction and net migration is seen as a major source of economic growth. Notwithstanding this population driven economic expansion for the region, the Northern Rivers Regional Development Board identifies the key to long term economic growth as the ability of the region to generate export orientated jobs, including tourism.

3.8.2 Regional Economic Modelling of Changes in Agricultural Land Use

Impacts associated with the shortlisted route options include some loss and severance of agricultural land use. An analysis of the regional economic effects arising from these changes was conducted using an agricultural production model combined with the Tweed Economic Development Corporation's regional economic model. Firstly the direct effects of each highway upgrade option on the annual gross value of agricultural production were identified for both areas directly affected by the options and the residual (severed) area of the affected lots, using land mapping identified in **Section 3.7.1**. This was then used as the basis for the modelling to calculate the flow on effects and the total regional effects. **Table 3.9** summarises the predicted economic impacts of each shortlisted route option for Byron/Ballina region.

The economic effect on the region has been calculated in terms of the impact on the Gross Regional Product (GRP). The GRP is an economic indicator that takes into account all industry 'value added' components, and is generally accepted as the economic measure of what the economy produces.

As shown in **Table 3.9,** the direct effect to agricultural production of the shortlisted route options is between $0.61 M to $1.54 M with impacts to the Byron/Ballina region's GRP between $0.24 M and $1.32 M. It is important to note that in any year agriculture contributes approximately 5% of the regional GRP, and that the total regional GRP across all sectors totals around $1.6 billion for the Byron/Ballina economy and $3.6 billion for the entire Northern Rivers region. The methodology and results of the regional economic assessment is described in *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Working Paper on Regional Economic Impacts of Changes in Agricultural Land Uses* (RTA 2006).

Table 3.9 Economic Impacts from the Change in Current Land Use for Byron/Ballina ($ million)

Route	A	B	C	D
Reduction in value of agricultural production (direct effect)	$1.41	$1.54	$0.62	$0.61
Flow-on effect through economy (indirect effect)	$1.31	$1.39	$0.56	$0.56
Total GRP effect	$1.23	$1.32	$0.52	$0.50

3.8.3 Local Business and Economy

The assessment of local economic impacts associated with the short list of route options is done on a qualitative basis and compares the relative impacts of the shortlisted options. The study takes into account the operating amenity of a business due to location, accessibility and interaction with the local landscape.

Highway upgrade options that move traffic away from Knockrow, Newrybar and Bangalow could generate positive amenity affects for those localities.

The overall accessibility of businesses in the study area would be similar for all the shortlisted options because all options incorporate only two interchanges. The movement of traffic away from the existing highway could improve the perceived safety of access for businesses on the old Pacific Highway, encouraging its use for tourism and recreational purposes.

The impact to local businesses would be largely dependent on the reliance of the business on passing traffic along the Pacific Highway. While there would be direct effects to businesses that rely heavily on passing highway traffic, the transfer and consolidation of such business activities could represent significant positive impacts for Newrybar and Bangalow.

The methodology and results of the local business impact assessment is described detail in *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Report on Qualitative Economic Impacts on Local Business* (RTA 2006).

3.9 Social and Demographic Characteristics

The study area lies partly within both the LGAs of Ballina (southern half) and Byron (northern half). These LGAs are experiencing substantial social and economic change along with other areas of the Northern Rivers (defined by Northern Rivers Regional Development Board as stretching from the southern end of the Clarence Valley to the Queensland border and west to the Great Dividing Range).

For the period 1991 to 2001, Ballina and Byron Shires respectively experienced 2.14% and 2.86% annual compound population growth. Between the 1996 and 2001 censuses, Ballina and Byron Shires' population growth was 7.3% and 9.7% respectively. According to the Northern Rivers Regional Development Board, Ballina and Byron LGA populations are forecast to grow at an average annual rate of 1.18% and 1.51% respectively over the next 25 years.

Data from the 2001 Census of Population and Housing (Australian Bureau of Statistics) was analysed to provide an overview of the demographic structure of the study area. Eight Census Collection Districts (CCDs) cover and, in most cases, extend beyond the boundary of the study area.

The key demographic characteristics of the study area CCDs relevant to the project are:

- Total population in 2001 of 4,134 persons.
- The age structure is more closely aligned with the younger age structure of Byron shire than to the older age structure of Ballina.
- Within the study area, less than 1% of the population identified themselves as indigenous.
- Approximately 54% of the employed labour force worked full time and 43% part time. There is a high level of unemployment and underemployment in both LGAs.

- The largest industry occupational category was the retail sector (14.2%) followed by agriculture (10.8%), accommodation and cafes (10.5%), manufacturing (9.3%) and health and community services (9.2%).
- There were generally lower proportions in weekly household income levels at the lower levels ($0 to $499) than was the case for the Ballina and Byron Shires and similar or slightly higher proportions (especially compared to Byron) in the higher household income levels ($1,000 and above).
- The population had marginally higher levels of educational attainment in the Bachelor degree and above categories than in the Richmond Tweed region or in the state overall.
- Car ownership levels (especially more than one car per dwelling) in the study area CCDs are generally higher than the rates recorded at the LGA, regional and state levels.

3.10 Noise and Vibration

This section summarises the existing conditions and constraints identified in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Noise Working Paper* (RTA 2006). Since the RODR, additional noise analyses were conducted on the shortlisted route options to more clearly identify comparative differences between the route options. This work included:

- Additional noise modelling for each of the route options which allowed for more detailed calculation of the community noise burden for each of the route options.
- Specific detailed modelling of tunnel approach options T1 and T2, particularly in relation to noise impacts on Ewingsdale.
- Preliminary study of the relationship between road gradient and the extent and level of 'peak noise' events from truck movements.
- Review of the DEC interpretation of the noise impact assessment.

3.10.1 Methodology

Initial highway noise levels were estimated using the Calculation of Road Traffic Noise (CoRTN) methodology which was used to predict the daytime and night-time traffic noise levels. Initial noise predictions were based on projected traffic flow rates and heavy vehicle percentages for 2025.

The noise modelling was used to calculate the horizontal distance from the highway at which critical noise levels correspond to Environment Protection Authority criteria and RTA 'acute' noise levels. This information was used to map buffer zones around all buildings in the area of investigation. The buffer zones represent the limits within which noise criteria would be exceeded at the buildings.

In addition to the traffic noise predictions and analysis, actual traffic noise levels from the existing highway were measured during two noise surveys undertaken in the study area over a period of four weeks. Hundreds of noise measurements were undertaken at approximately 35 representative locations. Noise loggers were also installed at five locations within the study area for longer-term noise measurements.

3.10.2 Existing Noise Environment

Noise from the existing highway currently affects properties up to 300-500 m from the existing highway alignment. Traffic noise is audible further from the highway particularly during the night-time.

The main noise constraints are the large number of residential properties in the study area, particularly adjacent to the existing highway alignment, and along the many minor roads in the area such as Ross Lane, Martins Lane, Old Byron Bay Road, Broken Head Road, Piccadilly Hill Road, Coopers Shoot Road, Byron Bay to Bangalow Road and St Helena Road.

The township of Bangalow, and the larger settlements of Newrybar and Ewingsdale are also significant noise sensitive constraints. There is an existing noise barrier adjacent to the highway at Ewingsdale to mitigate noise. Additionally, there are current proposals to provide a noise barrier in Newrybar, adjacent to the western side of the existing highway, and to extend the existing noise barrier at Ewingsdale.

Both Bangalow and Ewingsdale, and properties adjacent to the existing highway on St Helena Hill are affected by noise from truck engine braking from the steep gradients on St Helena Hill. Newrybar School, located on Broken Head Road, is also a noise sensitive constraint.

3.10.3 Detailed Noise Modelling

After the public display of the RODR, noise predictions were carried out for each of the shortlisted route options using the CoRTN road traffic noise model with SoundPlan environmental noise prediction software.

As the CoRTN methodology predicts 18hr or 1hr L_{A10} noise levels (10 percentile, or average maximum), corrections have been derived to convert the basic L_{A10} results to the 15hr and 9hr L_{Aeq} noise levels used by the Environment Protection Authority. The corrections are based on actual traffic flows and noise levels measured adjacent to the existing Pacific Highway corridor between Tintenbar and Ewingsdale in 2004 and 2005.

Noise level contours for the day and night-time periods for the shortlisted route options are provided in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Noise Working Paper* (RTA 2006).

3.10.4 Comparative Analysis of T1 and T2 Tunnel Options

More detailed noise modelling of tunnel approach options T1 and T2 was undertaken to assist in the differentiation of these two options.

The T1 alignment closely follows the existing highway with a 6.0% gradient. The T2 alignment is marginally closer to Ewingsdale (approximately 50 m), but has a much lower 4.5% gradient. It was initially expected that T2 would result in higher average noise levels in Ewingsdale since it was closer than T1; and because T2 has a much lower slope, that it would result in reduced noise emission and significant reductions in peak noise events from engine braking.

Predicted average night-time noise level contours ($L_{Aeq,9hr}$) for both T1 and T2, without any noise mitigation (i.e. no noise barrier), are included in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Noise Working Paper* (RTA 2006). The results confirm that the average noise impacts on Ewingsdale are marginally higher for T2 than for T1. This is due to T2 being nearer to Ewingsdale by about 50 m, and even though T2 has a lower road gradient, this is not sufficient to counterbalance the increased noise levels due to the closer proximity.

However, it is likely that when noise mitigation measures are applied to both the T1 or T2 options, then the noise impacts on Ewingsdale would be similar. The mitigation measure most likely to be adopted is a 4.5 m high noise barrier located to shield the Ewingsdale area from road noise.

3.10.5 Truck Engine Braking Events Relative to Road Gradient

A preliminary study was undertaken in December 2005 to examine the effects of road gradient on the incidence and loudness of truck noise, in particular engine compression braking. The aim of the study was to quantify the extent of the expected reduction in 'peak noise' events that might be achieved between the alterative T1 and T2 tunnel options, particularly adjacent to Ewingsdale. Truck engine braking noise is already a major community concern in this area.

Since no previous information regarding this effect was available in the literature, a series of night-time noise surveys were conducted on sections of the Pacific Highway between St Helena Hill and Chinderah with grades of 2.2%, 3.4%, 4.5% and 6%.

In summary the results indicate that:

- There is no significant reduction in the extent of engine braking from trucks at gradients lower than 6%, except at 2.2%.
- There is no significant difference in resultant peak noise levels for grades between 3.4% and 6%.
- Truck noise on uphill sections was on average higher than on downhill sections.

The five measurement locations and times were carefully chosen, within the limits of the survey area, to minimise the influence of external factors such as slope of preceding and following road grades and geometry, intersections and traffic flows. However, it must be understood that this was a limited study and that external factors and the effect of other traffic, as well as individual driver behaviour and driving characteristics, could still have a significant influence on the results.

Again, for the purposes of comparing T1 to T2, it appears that the difference in gradient is not likely to significantly affect the incidence or level of peak noise levels.

3.10.6 Implications of DEC Interpretation of Noise Impact Assessment

The noise assessment conducted on the short list of route options compares the options according to their general 'noise burden' on the community.

During the VMW and in response to the RODR, the DEC noted that it favoured route options that comply with the *Environmental Criteria for Road Traffic Noise* (ECRTN) and have the least impact on new receivers. It was agreed that the subjective effects of change in noise levels on receivers, particularly those that are currently unaffected, are not well understood and therefore difficult to evaluate quantitatively. DEC has however clarified that their principal consideration remains meeting the ECRTN.

The Relative Community Noise Burden (CNB) has been developed by Arup for highway infrastructure projects to consider the broad impact of increased noise levels at receivers who currently have relatively low or no current road noise. The Relative CNB measures the change at each receiver in road noise level caused by the options being considered. The Relative CNB is calculated based on the change in annoyance due to the change in noise level relative to some base (i.e. absolute) noise level. Since it is a community rather than specific alignment measure, it also takes into account the reduction in noise that results at some receivers due to the particular option being considered. For example, considering Option D, the sum of the increase in noise measured at each receiver within 500 m of the proposed Option D alignment is decreased by the sum of the reductions in noise for receivers near the existing Pacific Highway. The overall result is a reduction in the total community noise level even though the increases to the road noise levels at those receivers near Option D are substantial.

THE DEC acknowledges that the Relative CNB is a suitable method to assemble a large amount of complex information into a simple form; but the DEC notes that the Relative CNB should be considered in conjunction with other accepted approaches of tabulating and describing noise levels and the numbers affected by those levels and changes in noise levels. An alternative way to quantitatively assess the changes in road noise in line with the DEC statement may be to only measure the relative total increase in noise for each of the alignments without consideration of the reduction in noise in other areas. This approach provides a different perspective on the road noise issue. A comparison of these approaches is shown in **Figure 3.8** and **Figure 3.9**. **Figure 3.8** shows the summation of (unweighted) change in noise level for each route option, including reductions in noise levels along the existing highway. **Figure 3.9** is similar, but only sums the increase in noise level, with no allowance for reductions in noise that would be experienced adjacent to the existing highway.

In each case, options closer to the left of the graph perform best, while options to the right have a higher impact. When allowing for noise level reductions (see **Figure 3.8**), Option D performs best since it impacts a small number of properties and benefits from large reductions in noise levels near to the existing highway. However, when only noise level increases are considered (see **Figure 3.9**), then Option A performs best, since it is near to properties which are already exposed to noise from the existing highway.

Figure 3.8 Change in Noise Level, Shortlisted Route Options

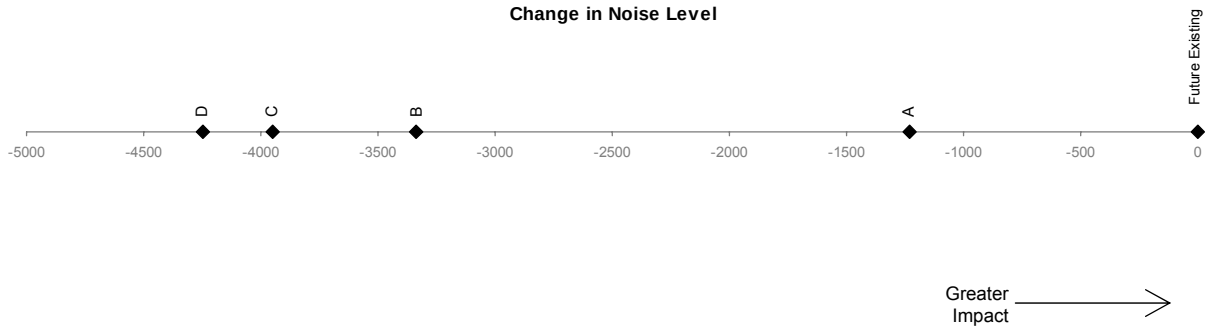
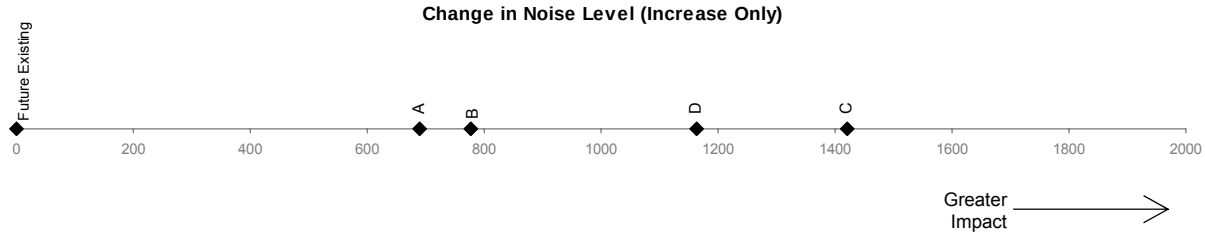


Figure 3.9 Change in Noise Level, (Increase Only), Shortlisted Route Options



The difference between the assessed impacts of the route options when measured according to different quantitative methods indicates the importance of considering these quantitative assessment tools in conjunction with traditional assessment approaches, community feedback and the broader engineering issues.

Nevertheless, the RTA considers that the Relative CNB approach is one of the most advanced and technically rigorous studies ever undertaken for route options assessment in NSW. It is based on scientific methodologies and research from overseas into the subjective impact in traffic noise level changes. The Relative CNB takes a holistic view of the impacts of road noise on the community while giving due consideration to the change in noise levels being experienced by new receivers. It is recognised that this is a very sensitive issue for the community and the community noise burden approach appears to provide a method of assisting to decide if it is 'worse' for road noise to increase substantially for a few new receivers, or a lesser amount for a large number of existing receivers.

3.10.7 Vibration

Blasting is likely to be necessary for the construction of the road tunnel. Blasting results in ground vibration and airblast (also called blast overpressure). The airblast is generally more noticeable than the ground vibration.

Where necessary, ground vibration and blast overpressure from tunnel blasting would be controlled within the guidelines from the ANZECC. These guidelines limit blast overpressure to 115 dB (lin, peak) at any residence, and ground vibration to 5 mm/s peak particle velocity (PPV). These

guidelines also restrict blasting to between 9 am and 5 pm on weekdays and Saturday, and recommend only one detonation per day.

3.11 Landscape and Visual Amenity

This section summarises the existing conditions and constraints identified in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Landscape and Visual Working Paper* (RTA 2006).

3.11.1 Landscape Character and Visual Constraints

The region's development over time has owed much to its varied natural landscape features and scenic character. Development has ranged from the earliest settlements associated with timber getting, dairying and whaling, to farming for sugar cane, tropical fruits, nuts, coffee and tea, and the more recent eco-tourism industry. The scenic nature and recreational potential of the natural environment, combined with the area's relaxed country lifestyle, continue to attract large numbers of people to the area, both in terms of visitors and new residents. It is these factors that make the proposed upgrade of the Pacific Highway between Tintenbar and Ewingsdale sensitive from a landscape and visual amenity perspective.

Landform

The majority of the study area is located on an elevated plateau which is defined by a steep escarpment on its northern and eastern edges, falling to a relatively flat coastal plain. The escarpment rises above the coastal plain, ranging in height between 80 m and 180 m above sea level. It provides a dominant landform feature in the area and accounts for much of the area's scenic quality.

The coastal flats form part of a wetland system around North Creek, which is at the heart of the Ballina Nature Reserve south of Ross Lane and located inland between the coastal dunes and headlands and the escarpment. A similar wetland system occurs north-east of the study area, extending as a flat coastal plain at the foot of the escarpment from Cumbebin Swamp near Byron Bay to Belongil Swamp, Tyagarah Nature Reserve and further north.

The landscape of the elevated plateau is characterised by a steeply undulating landform dissected by numerous watercourses. As a result of this, the escarpment itself as well as the ridges and higher slopes on the plateau are exposed to many viewpoints. Conversely, the lower slopes and valleys of the plateau are often concealed from many viewpoints in the locality. The elevated areas within the study area also provide expansive regional views towards the Pacific Ocean and inland. Many properties situated on the upper slopes of the escarpment in particular, enjoy spectacular and uninterrupted views towards the Pacific Ocean and across the coastal flats, headlands and ridges.

The various landforms within the study area and their degree of exposure to views are shown in **Figure 3.10**, including prominent hills and ridges.

Vegetation

On the elevated plateau, the types and degree of vegetation cover combined with the steeply undulating landform results in a highly diverse and scenic landscape with a lush cover of both indigenous and exotic vegetation, interspersed by more open areas of paddocks or plantations. A recurring feature along the current highway is the significant number of macadamia tree plantations whose grid arrangements lend a unique character to the agricultural landscape.

The escarpment slopes are generally steeper and less suitable for agriculture, resulting in a combination of open grassed paddocks with clumps of exotic and native trees, the latter primarily on the steeper slopes. The coastal flats, by contrast, are characterised mostly by sugar cane, however, macadamia plantations have also been planted on the coastal flats in recent years. These are interspersed with stands of trees, remnant swamps or wetlands, and reed-lined trenches and drains.

Land cover is important in determining the visual absorptive capacity of the landscape and is shown in **Figure 3.11**.

Settlement Patterns

Within the study area there are several small towns and villages – Newrybar, Ewingsdale, Bangalow and Knockrow. Residential properties outside these areas tend to concentrate along local roads through the study area, creating small hamlets. These hamlets usually follow the ridge lines of the high plateau where the elevation offers panoramic views of the surrounding landscape and in some cases the ocean. Land use, settlement and circulation patterns, shown in **Figure 3.12** are important in assessing the visual sensitivity of viewers to an upgraded highway.

3.11.2 Visual Impact Assessment

The visual and landscape impact of the highway upgrade would depend on the form and alignment of the highway (its visual effect) and on the number and sensitivity of potential viewers (the visual sensitivity of viewers).

Two major groups of viewers are considered in the analysis: the motorists who experience the highway from within the road corridor while travelling at high speed; and viewers outside the road reserve (including local residents, visitors and workers) who would see the highway as an element cutting through the landscape. **Table 3.10** lists the measurable components that form the basis for the visual assessment of the route options, and provides guidance on the significance attributed to these measurable components.

Table 3.10 Classification of Visual Impact Measurable Components

	Measurable	Key factors
Visual sensitivity of viewers	Scenic quality of the landscape and landscape character type	Changes to more scenic landscape types would be viewed more critically by external viewers; however scenic landscape would be appreciated by road users. The study area is divided into five landscape character types of varying scenic quality. The escarpment and undulating hills and ridges with extensive areas of mature vegetation were considered the most significant landscape types.
	Number and sensitivity of viewers	The location of public lookouts, towns and villages, tourist routes, local roads and dwellings all contribute to the number of potential viewers who would be sensitive to changes in the visual environment and the sensitivity of those viewers to such changes.
	Distance from existing highway infrastructure	The distance of an area from the existing highway provides a measure of the influence of the existing highway and associated infrastructure and activity levels. Areas further away form the existing highway are less affected and generally experience greater amenity.
Visual effect of the option	Degree of exposure of the route	The exposure of the highway determines the degree to which it is visible from surrounding areas. The study area is divided into five Landscape Setting Units which provide different degrees of exposure or concealment for the route alignment. The escarpment and exposed ridges and hills with little or no vegetation cover are the landscape types where the highway would be most widely exposed to views. However, these areas also provide better viewing opportunities for the motorist.
	Scale of new infrastructure: cuttings and embankments	Large scale infrastructure would have a greater visual effect on both the motorist and on viewers in the surrounding landscape.

Figure 3.10 Landform and Visual Exposure

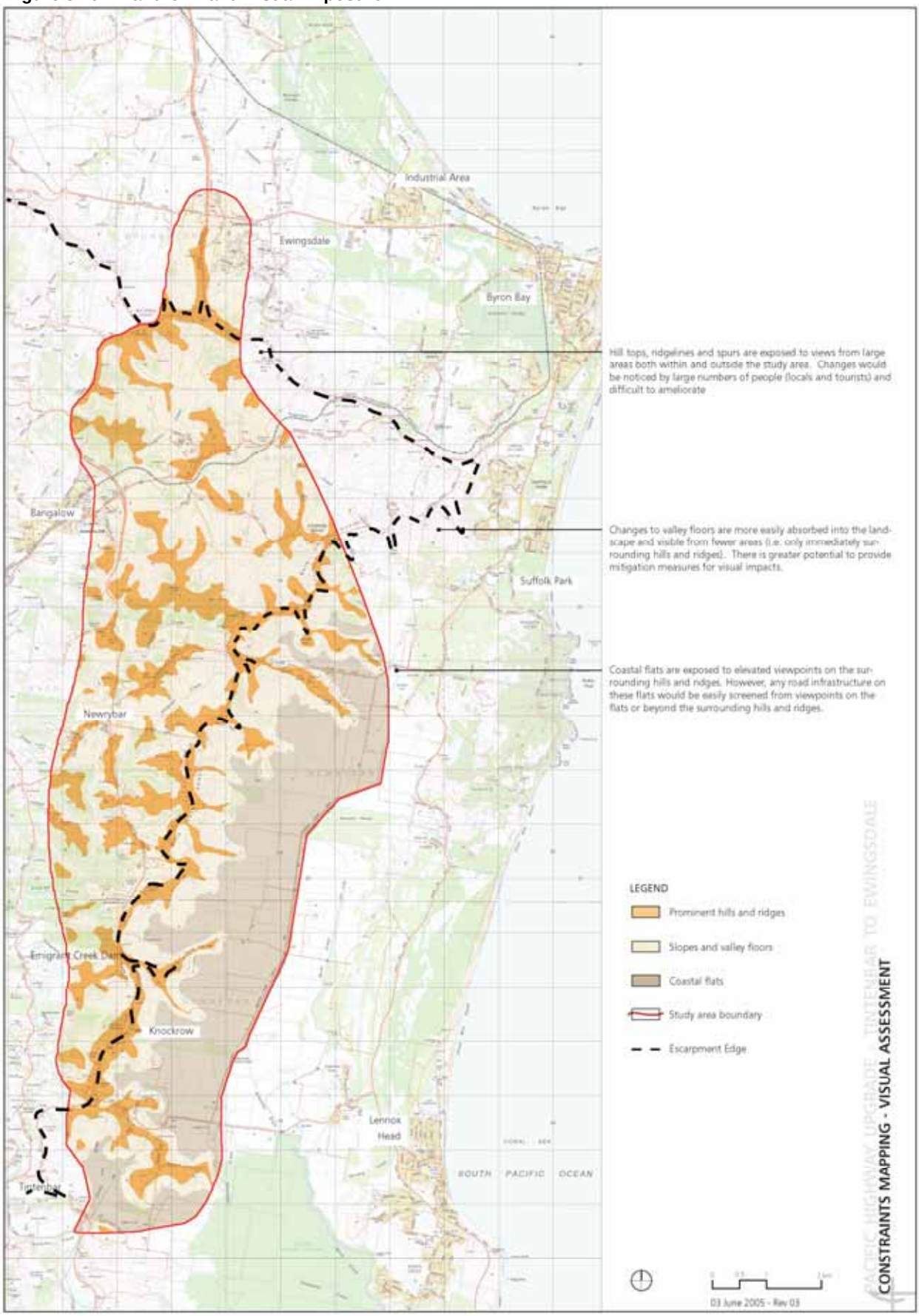


Figure 3.11 Landcover and Visual Absorption Capacity

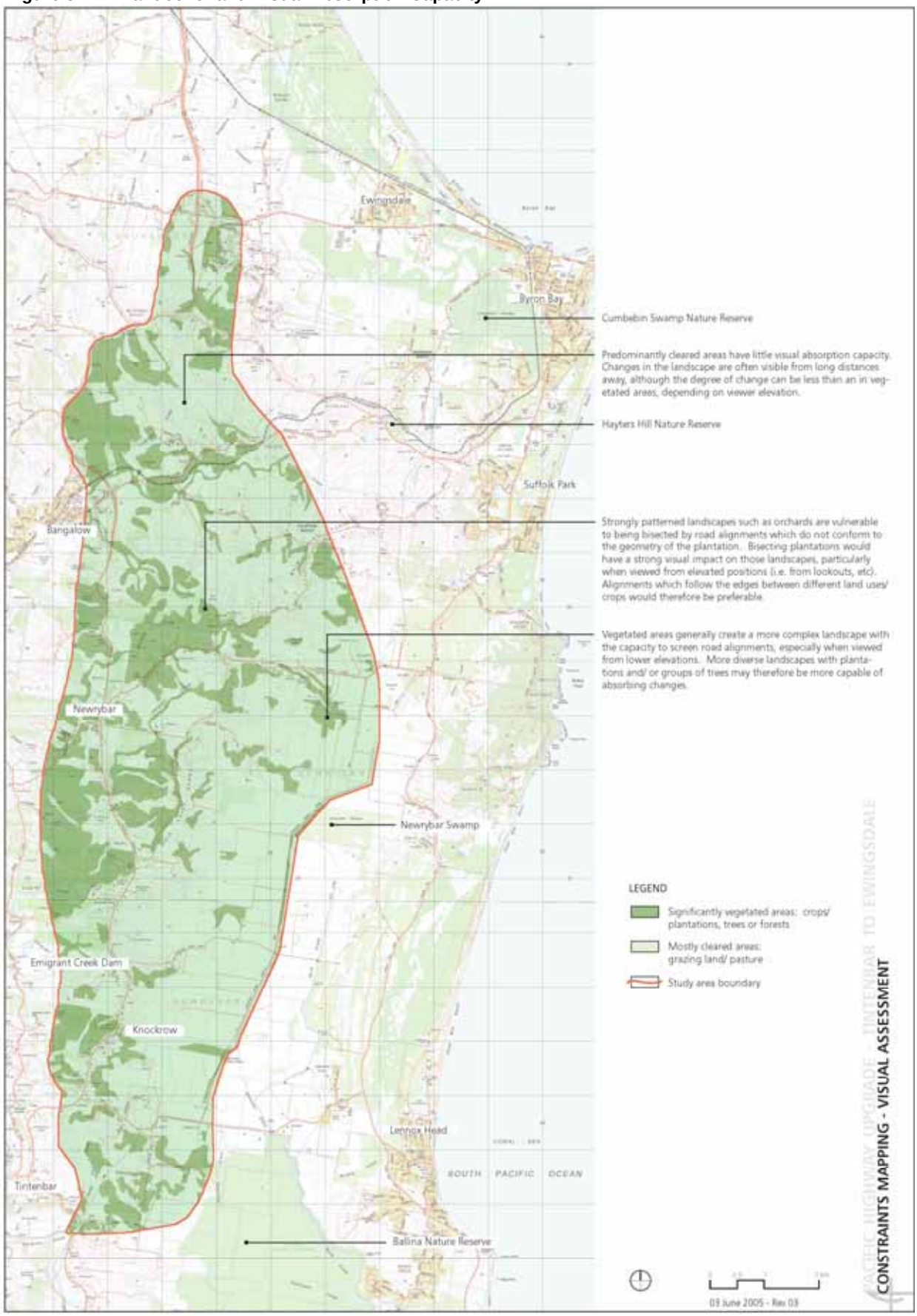
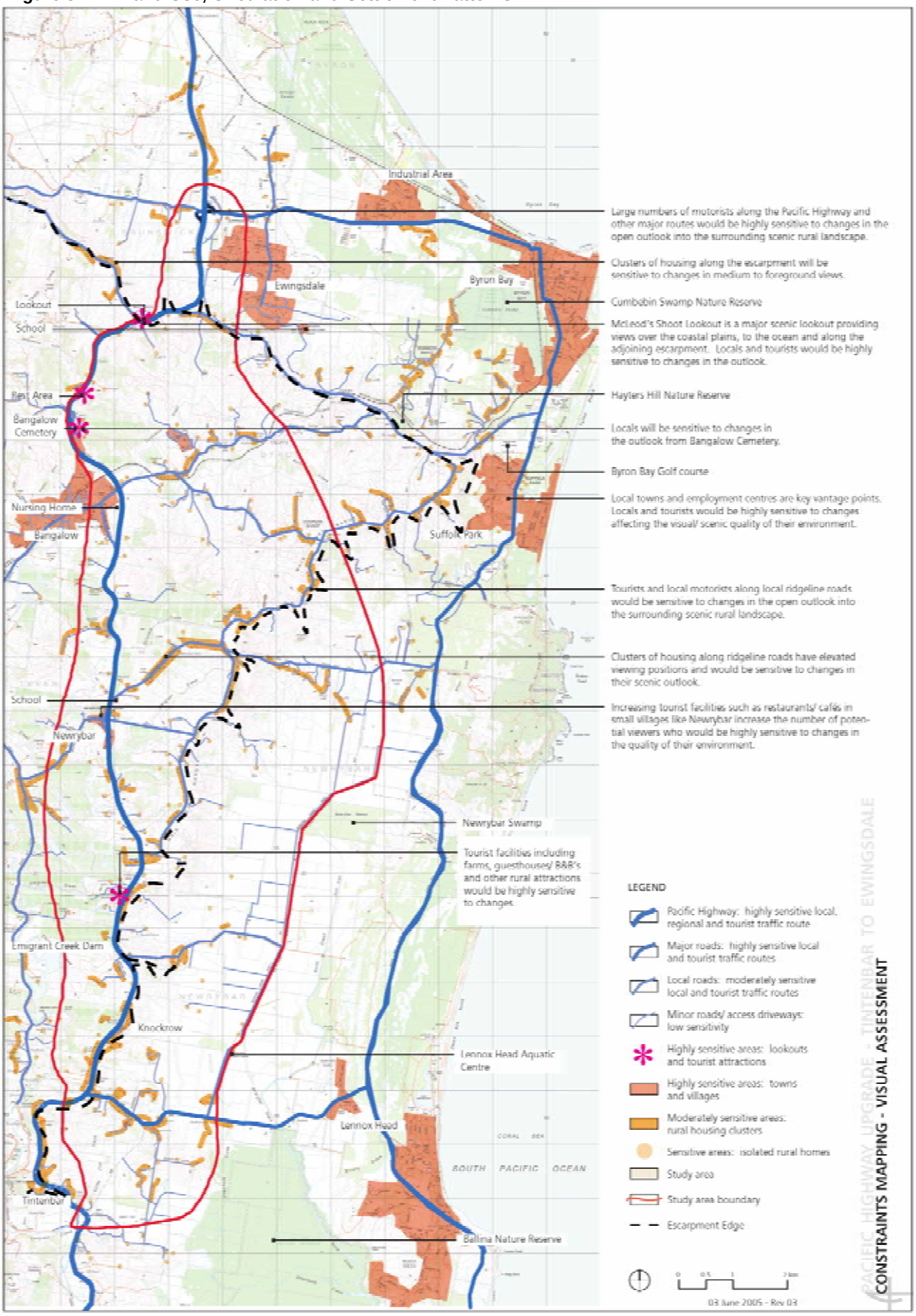


Figure 3.12 Land Use, Circulation and Settlement Patterns



Transport and Engineering Characteristics

This section describes the following transport and engineering related characteristics in the study area:

- Traffic and safety.
- Topographic conditions.
- Soils and geotechnical.
- Hydrology and flooding.
- Public utilities.

3.12 Traffic Context and Safety

This section summarises the existing conditions and constraints identified in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Traffic Working Paper* (RTA 2006) and updates the information presented in the RODR. In particular, the forecast future traffic volumes for the Pacific Highway detailed in the RODR have been refined to identify the likely traffic volume split between the upgraded and existing highway as well as any additional traffic diverted from other routes due to the Pacific Highway Upgrade program, including the Ballina Bypass.

As the concept designs for the short list of route options were developed and local access arrangements defined, daily traffic volumes for local roads intersecting the existing highway have also been estimated for each option, based on the 2004 surveyed volumes and likely change in travel patterns within the local area.

In addition to this, new accident data has been analysed for the most recent five-year period available (January 2000 - December 2004).

3.12.1 Existing Highway Conditions

With the exception of the Bangalow Bypass and the Ewingsdale interchange, the Pacific Highway between Tintenbar and Ewingsdale is single carriageway roadway, generally with one lane in each direction. Overtaking lanes are provided at intermittent locations along the length.

Figure 3.13 St Helena Hill

The existing posted speed limit is generally 100 km/h with an 80 km/h zone traversing St Helena Hill (currently posted 60km/h for northbound traffic due to recent accidents). A significant length of the highway within the study area has sub-standard geometry and many speed warning signs are posted along its length.

The photograph in **Figure 3.13** shows the geometry of St Helena Hill, which has the steepest grades within the study area, combined with relatively tight horizontal geometry. **Figure 3.14** and **Figure 3.15** graphically display the grades, vertical curves, and horizontal curves of the existing highway. Results have been colour coded with regard to their compliance to both the RTA's minimum and desirable design standards for the project.

The Combined Geometry Rating graph, shown on **Figure 3.15** shows that over 50% of the existing highway does not comply with at least one minimum design standard.

Other examples of poor geometry are evident on the existing highway. This includes insufficient sight distances, particularly at the numerous at-grade intersections and driveways with direct access to the highway.

There are 30 at-grade intersections and 88 property driveways directly accessing the highway along the length of the study area creating a large potential for accidents.

3.12.2 Existing Traffic Conditions

Historical traffic data has been collected from a number of sources. These include:

- Permanent and temporary traffic counting stations, maintained by the RTA.
- Additional traffic counts undertaken specifically for the Project.
- Origin and destination surveys undertaken for the Project.

Traffic count data from 2004 indicate that the current two-way Annual Average Daily Vehicle (AADV) volume is in the order of 16,500 vehicles north of Bangalow, and 11,500 vehicles south of Bangalow. The percentage of heavy vehicles that comprise these volumes on a typical day is in the order of 14% (2,300 vehicles) north of Bangalow, and 16% (1,900 vehicles) south of Bangalow.

The permanent traffic counter on the Pacific Highway at Knockrow (south of Bangalow – RTA site 04.060) provides information on the annual, weekly and daily traffic fluctuations on the highway. Traffic flows on the highway reach a peak during the major public holiday periods such as Easter, Christmas and school holiday times, with peak traffic volumes 50% to 100% greater than the average weekday volumes. The highest daily volume recorded (to date) was during the 2004 Easter period, on 8 April 2004, when in total 20,327 axle pairs were recorded for the two directions. This value is around 50% higher than annual average and is consistent with other parts of the Pacific Highway affected by holiday traffic.

During the 30th Highest Hourly Volume for 2003 (the design hour), the Pacific Highway operates at Level of Service C between Tintenbar and Ewingsdale, suggesting relatively good traffic conditions for motorists Level of Service is a qualitative measure describing the operational conditions within the traffic stream, based on service measures such as speed and travel time, freedom to manoeuvre, traffic interruptions comfort and convenience).

In terms of vehicles per hour, weekday volumes are relatively consistent throughout the 8am to 5pm period, with minor peaks around 8-9am and 3-4pm, whilst at weekends traffic volumes are relatively consistent for the period 10am to 4pm. During counts on the Pacific Highway in November 2004, south of Bangalow, the average peak hour traffic volume (measured in vehicles) was 8.6% of the daily total for the weekend and 7.8% during the week. The data shows that, for non-holiday weekdays, traffic is relatively evenly spread throughout the day, without a major ‘commuter peak' that is evident in metropolitan regions.

Figure 3.16 shows the fluctuations in average traffic volumes throughout the day. This represents a combination of weekday and weekend traffic.

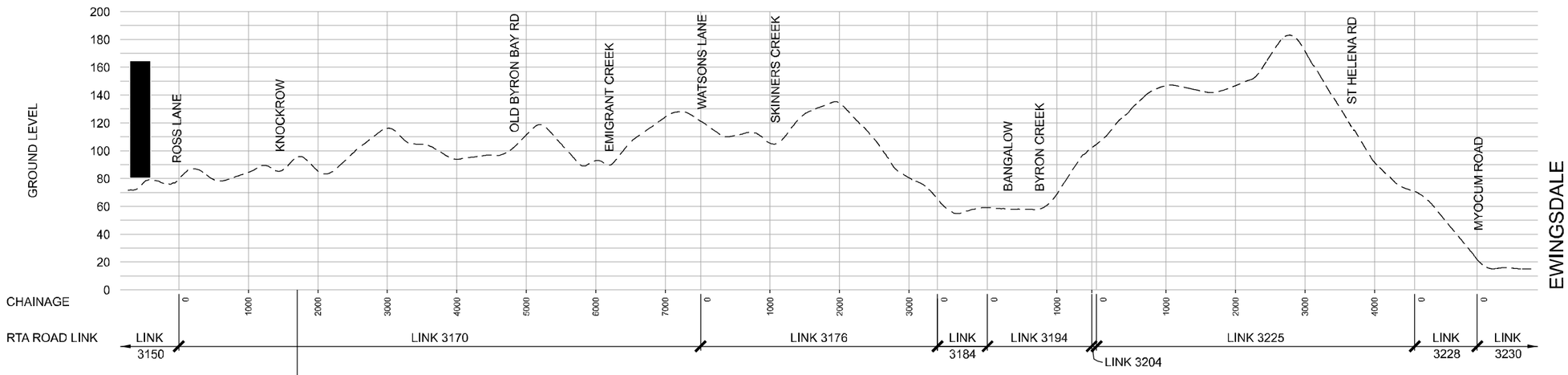
Origin and destination surveys were conducted to gain an understanding of local traffic movements and connections on the Pacific Highway within the study area. The following key observations made were:

- The high number of vehicles using the highway to travel between Bangalow and Ewingsdale (around 1350 vehicles between 7am and 7pm).
- The number of vehicles travelling between Coolamon Scenic Drive and Ewingsdale (around 300 vehicles between 7am and 7pm).
- The number of vehicles travelling between Newrybar/Broken Head Road and Bangalow (around 300 vehicles between 7am and 7pm).

Analysis of classified count data south of Bangalow (see **Table 3.11**) indicates that heavy vehicles comprise a significant proportion of the traffic stream; approximately 16% of the average daily traffic volume during typical non-holiday periods. The analysis also shows that this percentage approaches 40% when looking at night traffic only.

Table 3.11 Analysis of Classified Count Data (November 2004)

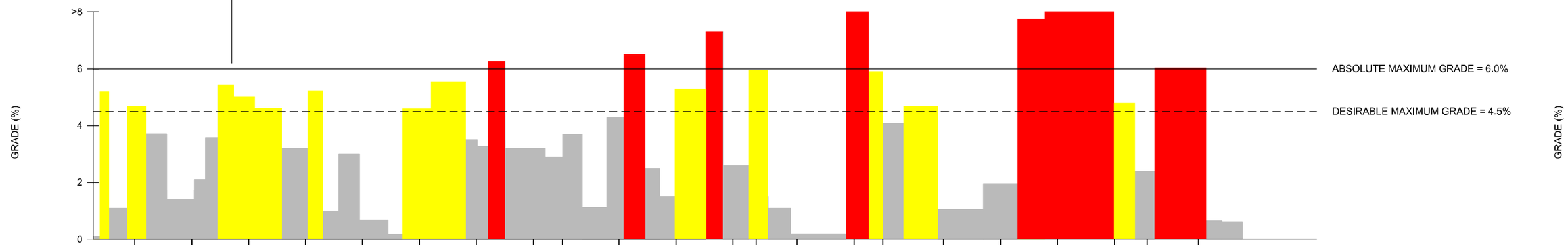
Time Period	Heavy Vehicle Measure	Direction		Total
		Northbound	Southbound	
Average	Heavy vehicles as percentage of daily vehicles	16% (814)	16% (871)	16%
Night only	Night heavy vehicles as percentage of total night vehicles	49%	31%	41%
(10pm – 7am)	Night heavy vehicles as percentage of total daily heavy vehicles	39% (320)	20% (178)	30%
Weekend	Weekend heavy vehicles as percentage of weekend total vehicles	9% (444)	8% (433)	9%
	Percentage heavy vehicles during weekend peak hour (12pm)	3% (15)	7% (33)	6%



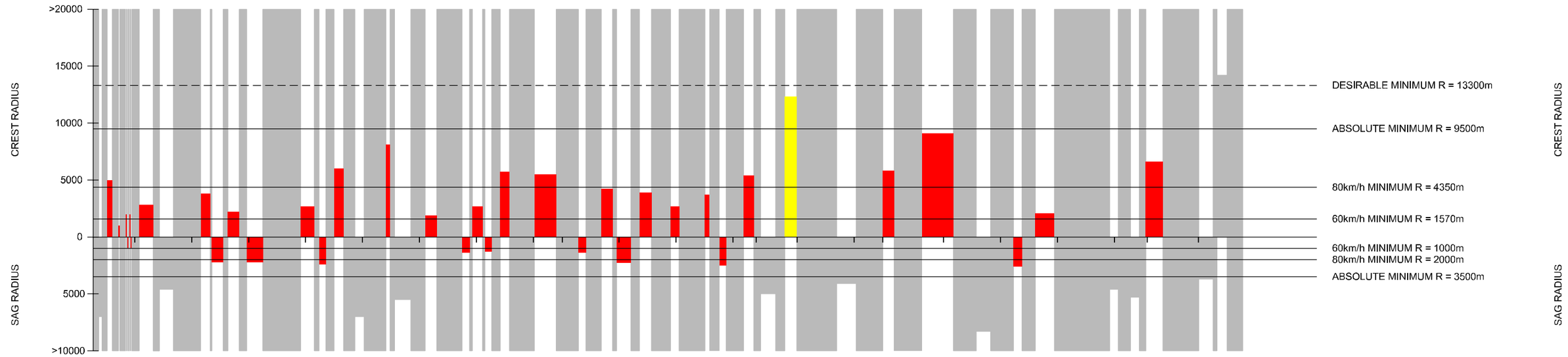
EXISTING PACIFIC HIGHWAY LONGSECTION

LEGEND

- NON-COMPLIANCE TO MINMUM STANDARD
- NON-COMPLIANCE TO DESIRABLE STANDARD
- COMPLIANCE TO DESIRABLE STANDARD



EXISTING GRADES



EXISTING VERTICAL GEOMETRY

Issue	Date	By	Chkd	Apprl
02	24/11/05	BK		
60km/h & 80km/h MINIMUM R ADDED				
01	26/08/05	BK	BM	BM
ORIGINAL ISSUE				

Client

Job Title
PACIFIC HIGHWAY UPGRADE
TINTENBAR TO EWINGSDALE

Scale at A0 N.T.S

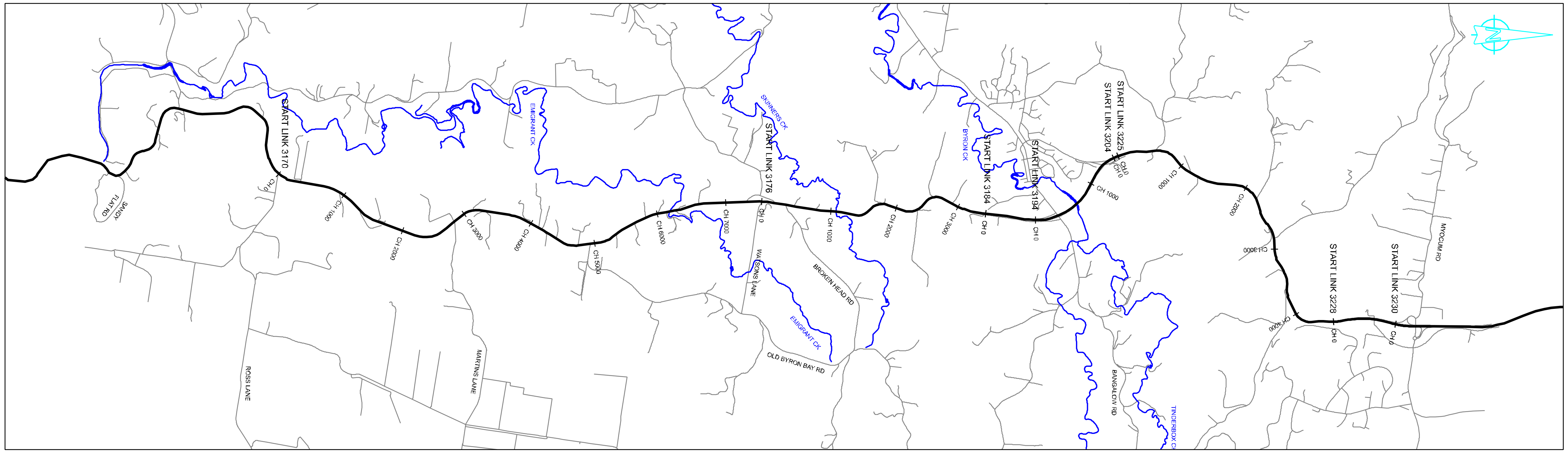
Plot ID

ARUP
Arup, Level 10, 201 Kent St
Sydney, NSW, 2000
Tel +61(0)2(9)320 9320 Fax +61(0)2(9)320 9321
www.arup.com.au

Drawing Title
EXISTING HIGHWAY GEOMETRY
SHEET 1 OF 2

Drawing Status
FOR INFORMATION ONLY

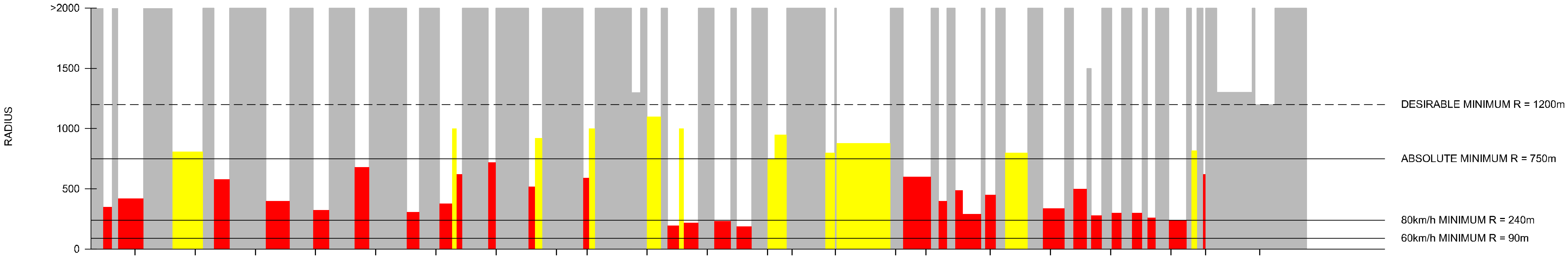
Job No	Drawing No	Issue
84046	Figure 3.14	02



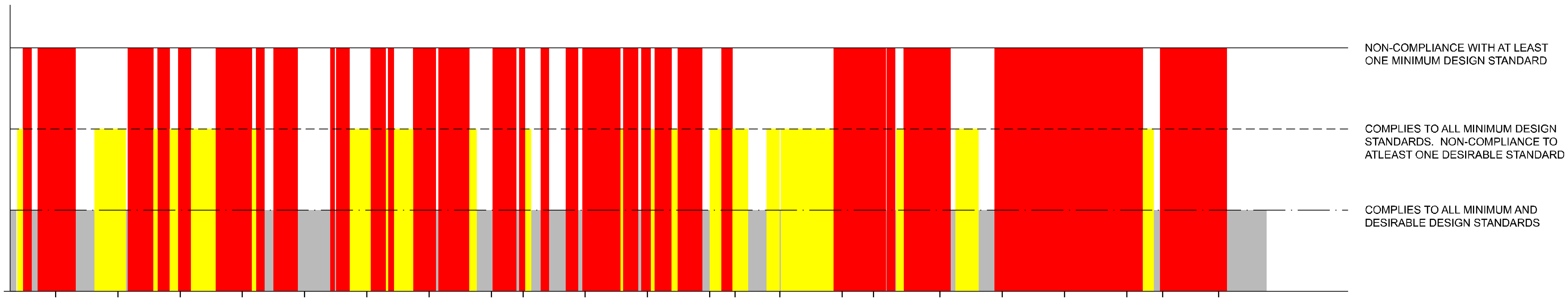
LEGEND

- NON-COMPLIANCE TO MINMUM STANDARD
- NON-COMPLIANCE TO DESIRABLE STANDARD
- COMPLIANCE TO DESIRABLE STANDARD

EXISTING PACIFIC HIGHWAY PLAN



EXISTING HORIZONTAL GEOMETRY



COMBINED GEOMETRY RATING

Issue	Date	By	Chkd	Appd
02	24/11/05	BK		
	60km/h & 80km/h MINIMUM R ADDED			
01	26/08/05	BK	BM	BM
	ORIGINAL ISSUE			

Client

Job Title
PACIFIC HIGHWAY UPGRADE
TINTENBAR TO EWINGSDALE

Scale at A0 N.T.S

Plot ID

ARUP

Arup, Level 10, 201 Kent St
Sydney, NSW, 2000
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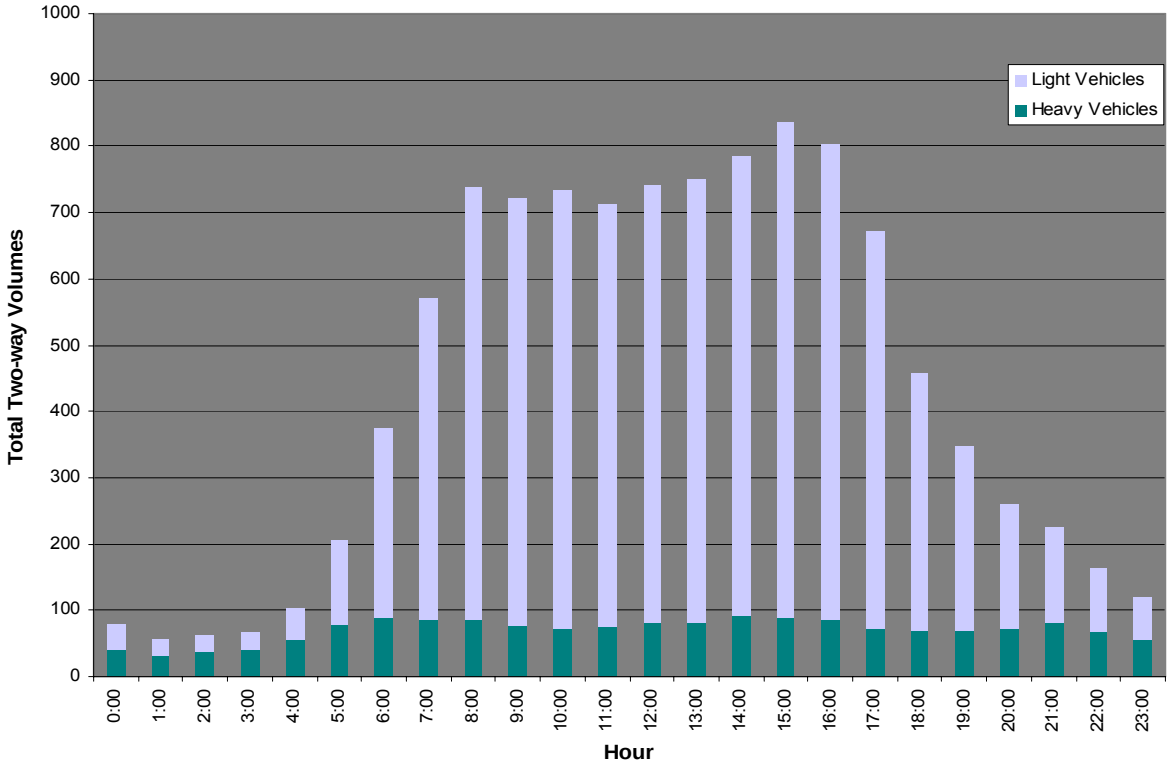
Drawing Title
EXISTING HIGHWAY GEOMETRY
SHEET 2 OF 2

Drawing Status
FOR INFORMATION ONLY

Job No 84046 | Drawing No Figure 3.15 | Issue 02

Figure 3.16 Average Hourly Traffic Volumes on the Pacific Highway



3.12.3 Accident History

Accident analysis has been undertaken and is based on accident history for the 5-year period from January 2000 to December 2004. It comprises RTA reported accident data between Sandy Flat Road and the start of the dual carriageway just south of the Ewingsdale Interchange. During this period a total of 175 accidents were recorded along this section of the existing Pacific Highway. The accidents included:

- 7 accidents resulting in 7 fatalities and 14 injuries.
- 67 accidents resulting in injuries.
- 101 accidents not resulting in injury, but where a vehicle was towed away.

A summary of the recorded accident data is as follows:

- There were significantly more accidents at the northern and southern ends of the study area compared to the middle section. For the 3.6 km section between Sandy Flat Road and Ross Lane 44 accidents were reported, and for the 6 km section north of Bangalow 79 accidents were reported. This compares with 52 accidents for the 12 km middle section between Ross Lane and Bangalow.
- 3 of the 7 fatal accidents were the result of a head-on collision.
- 3 of the 7 fatal accidents occurred north of Bangalow.
- 2 of the 7 fatal accidents involved a heavy vehicle.
- Speed was a contributing factor to 4 of the 7 fatal accidents while fatigue was a contributing factor to 1 of the 7 fatal accidents.
- The most common accident description was vehicles travelling off path on a curve or turning, followed by collision with a vehicle from the same direction.

When compared with the annual average daily traffic volumes within the study area, the accidents above represent accident rates of 62 accidents per 100 Million Vehicle Kilometres (MVK) travelled between Sandy Flat Road and Ross Lane, 57 accidents per 100 MVK north of Bangalow, 24 accidents per 100 MVK between Ross Lane and Bangalow, or an average of 41 accidents per 100 MVK for the study area. This rate is above the statewide accident rate for a rural 2-lane undivided road of 32.8 accidents per 100 MVK, and above the RTA's Pacific Highway target objective of 15 accidents per 100 MVK.

3.12.4 Traffic Forecasts

In November 2003, a report entitled State Highway No 10, Pacific Highway at Ewingsdale – Predictions of Future Traffic Volumes was prepared for the RTA (RTA 2003b). This report examined historical traffic count data in the vicinity of the Ewingsdale Interchange, as well as additional traffic counts undertaken by the RTA in order to examine the effects of the Yelgun to Chinderah upgrade (at Kankool and Nabiac). The report concluded that there was a 'step' in traffic growth (both light and heavy vehicles) on the Pacific Highway as a result of the opening of the Yelgun to Chinderah and recommends that future traffic growth on the highway be treated as linear.

Traffic forecasts for the Pacific Highway between Tintenbar and Ewingsdale have used the recommended linear growth rate of 3.2%. **Table 3.12** presents the forecasted AADV for the existing highway, along with the corresponding Levels of Service, if no upgrade was to occur from 2003 through to 2032. The analysis indicates that the existing two-lane Pacific Highway will reach Level of Service E around 2018. Level of Service E occurs when traffic flows are at or close to capacity. As the road approaches this level of capacity there is virtually no freedom to select desired speed or manoeuvre within the traffic stream. Even small disruptions to traffic flow would result in flow-on effects that would cause excessive queuing and delays to motorists.

Table 3.12 Forecasted Annual Average Daily Vehicles (AADT)

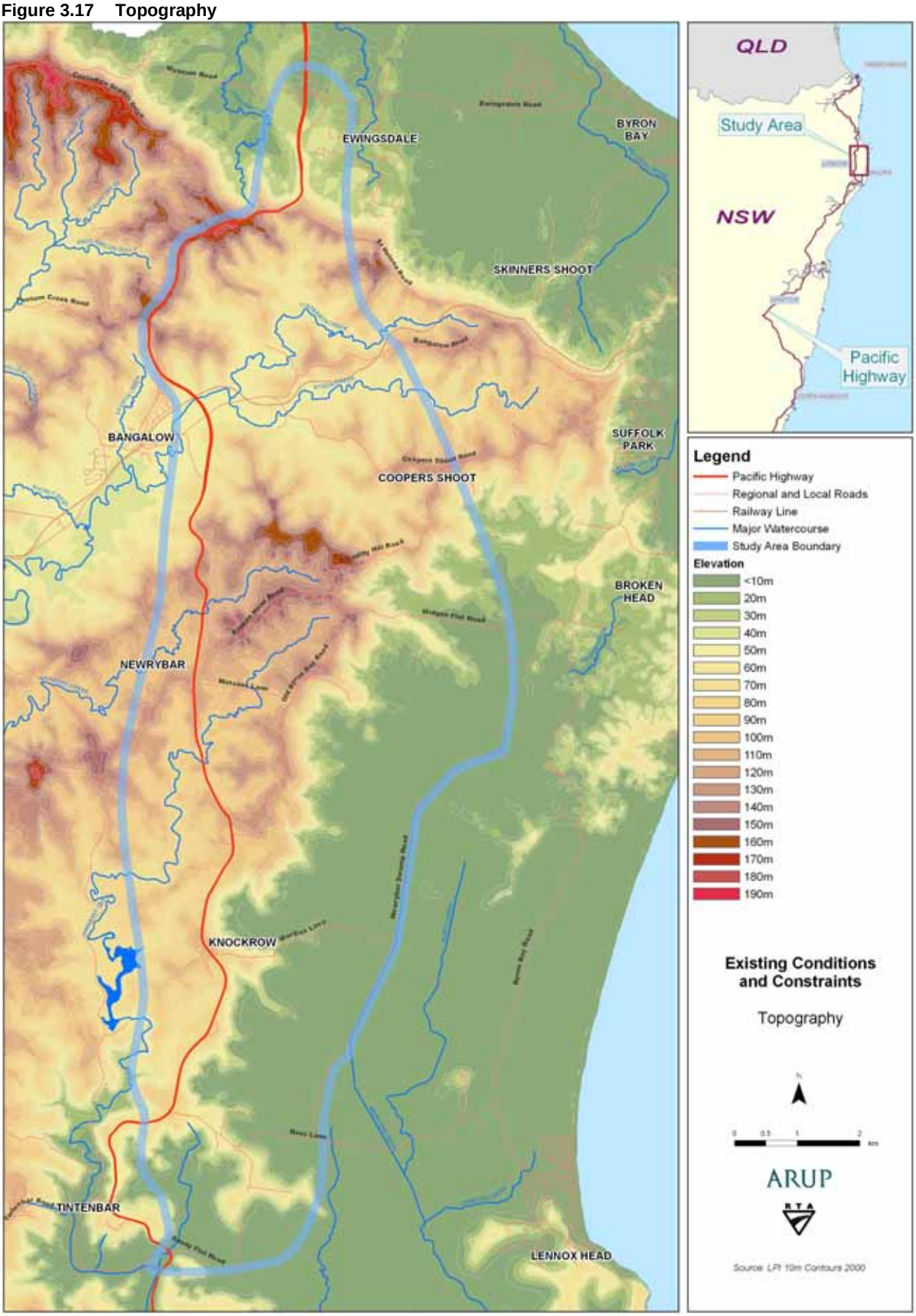
Forecast Year	AADV	Two-way peak hour volume	Level of Service for existing highway
2003 (Base design year)	11,000	1,450	C
2012	15,050	1,750	D
2022	18,900	2,175	E
2032	22,750	2,600	E

3.13 Topographical Characteristics

The main topographical characteristics in the study area are summarised below (see **Figure 3.17**):

- Significant level differences at the escarpments at the edges of the Alstonville plateau where the terrain falls to the coastal plain. The height of the escarpment varies within the study area from about 75 m at the southern escarpment near Ross Lane, 75 to 150 m on the eastern side and 100 to 150 m at the northern escarpment at St Helena. Even at the locations where the escarpment is lowest, a sustained climb over about 1.5 km would be required at the desirable maximum grade of 4.5%. The major difficulty from an engineering perspective is to develop alignment options which achieve the desirable maximum grade while limiting the cut and fill depths. For geotechnical reasons related to stability and maintenance it is generally preferable for the depths of cuttings to be no more than about 30 m and the height of fills to be no more than about 10 to 15 m. For alignments where cutting depths would have to exceed 30 m a tunnel might be required, and a viaduct might be required where fill depths on an alignment would exceed 10 to 15 m. Extensive earthworks, as well as tunnels and viaducts, can add significantly to costs and visual impacts and thus provide a significant constraint.
- The Alstonville plateau is incised by a number of streams which generally flow across the plateau from the north-east towards the south-west forming a series of valleys and ridges. The general direction of the highway is north-south, which means that the highway must cross these valleys and ridges. As with the escarpment, the major difficulty is to develop alignment options which achieve the desirable maximum grade while limiting the cut and fill depths. The adjacent valleys of Tinderbox Creek and Byron Creek at the north end of the study area are the most pronounced. The valley floors are 80 to 100 m lower than the ridge south of Bangalow and 70 to 120 m lower than the St Helena ridge. The ridges and valleys associated with Skinners Creek and Emigrant Creek to the south also cross the plateau from the north-east towards the south-west but are less incised and provide a lesser constraint to alignments.
- The engineering constraints presented by the significant level differences at the escarpment and on the valleys and ridges crossing the plateau are compounded by the steep slopes on most sections of the escarpment as well as on the sides of the Tinderbox Creek and Byron Creek valleys, generally exceeding 20% and exceeding 33% in some isolated pockets. High cuts and fills in these steep areas, especially where the cuts and fills are across the sides of these slopes, are difficult from a geotechnical perspective and can result in long term stability and maintenance issues.

Figure 3.17 Topography



3.14 Geology, Soils and Geotechnical

This section summarises the existing conditions and constraints identified in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Geotechnical Working Paper* (RTA 2006) and updates the information presented in the RODR. Additional geotechnical investigations conducted include:

- Further assessment of areas of potential landslide hazards based on aerial photograph interpretation using the newly available May 2005 aerial photographs and ground truth observations.
- Additional slope stability investigations along Options C and D.
- Additional investigations for Section A/B.
- Refined assessment of soft soil engineering requirements, based on embankment heights assessed from the flood study discussed in **Section 3.15**.
- Refinement of location of springs and further consideration of possible impacts on springs and groundwater.

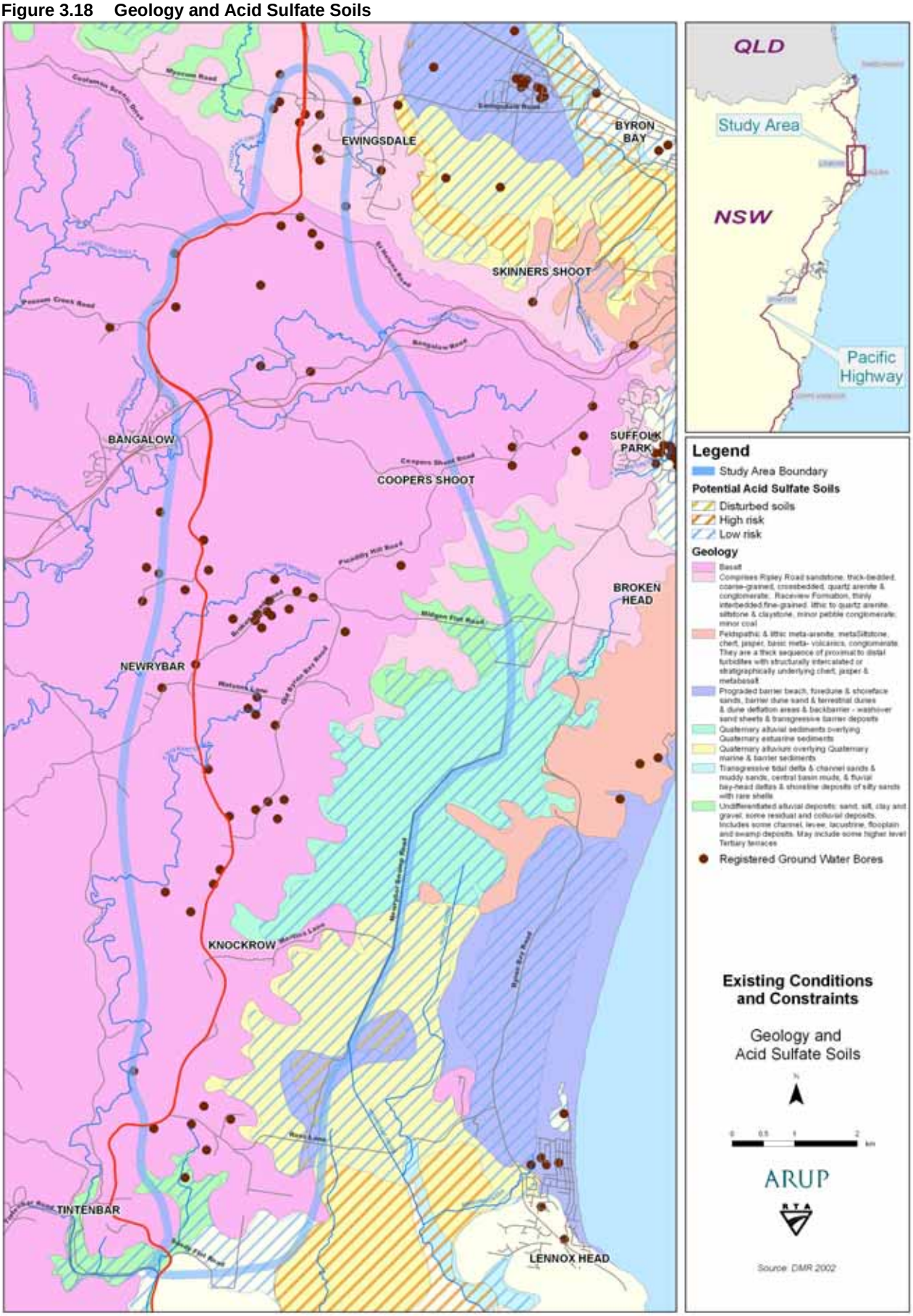
3.14.1 Geological and Soil Condition

The geological and soil conditions in the study area are described below in **Table 3.13** and mapped in **Figure 3.18**.

Table 3.13 Geological and Soil Characteristics

Terrain Unit	Topography	Geology	Soils
Floodplain	Low-lying floodplain east of the escarpment foothills	Quaternary alluvial sediments overlaying Quaternary estuarine sediments and Quaternary marine and barrier sediments	Alluvial, estuarine and marine soils; organic and non-organic clay, sand, indurated sand (weakly cemented with humic ferrous oxide); and stiff to hard clay and silt. Potential Acid Sulfate Soils
Escarpment	Distinctive steep slopes, punctuated by spurs and gullies	Argillites/greywackes of the Neranleigh-Fernvale Group present within 20 m beneath the lower slopes and spurs. Sandstone of the Ripley Road Sandstone and Raceview Formations form outcrops. Some basalt outcrops as well	Residual soils, colluvium or landslide debris
Plateau	Elevated plateau characterised by low rolling hills dissected by moderately deeply incised gullies and valleys, with some elevated ridges and hills. Topographic relief generally increases from south to north	Basaltic rock of the Lismore basalt	Residual soils

Figure 3.18 Geology and Acid Sulfate Soils



3.14.2 Springs and Groundwater

The location of springs within the study area is based on mapping by the Bureau of Rural Sciences. The mapping has been refined within the route option corridors based on observations from the May 2005 aerial photographs and information provided by landowners (see **Figure 3.19**).

The route options have the potential to impact on springs and groundwater regimes at the location of deep cuts under the following scenarios:

- If the cut penetrates below the groundwater table.
- If the cut coincides with the location of springs.
- If the cut is within the zone of influence of groundwater flow to a spring and impedes the groundwater flow to the spring.
- If the cut interrupts natural drainage flows from springs located uphill of the cut.
- Cuts that extend below the groundwater table have the potential to cause local drawdown of the groundwater table, because they will behave like a drain. The extent to which groundwater flows are impacted will depend on the topography at the cut and the depth of the cut below the groundwater table.

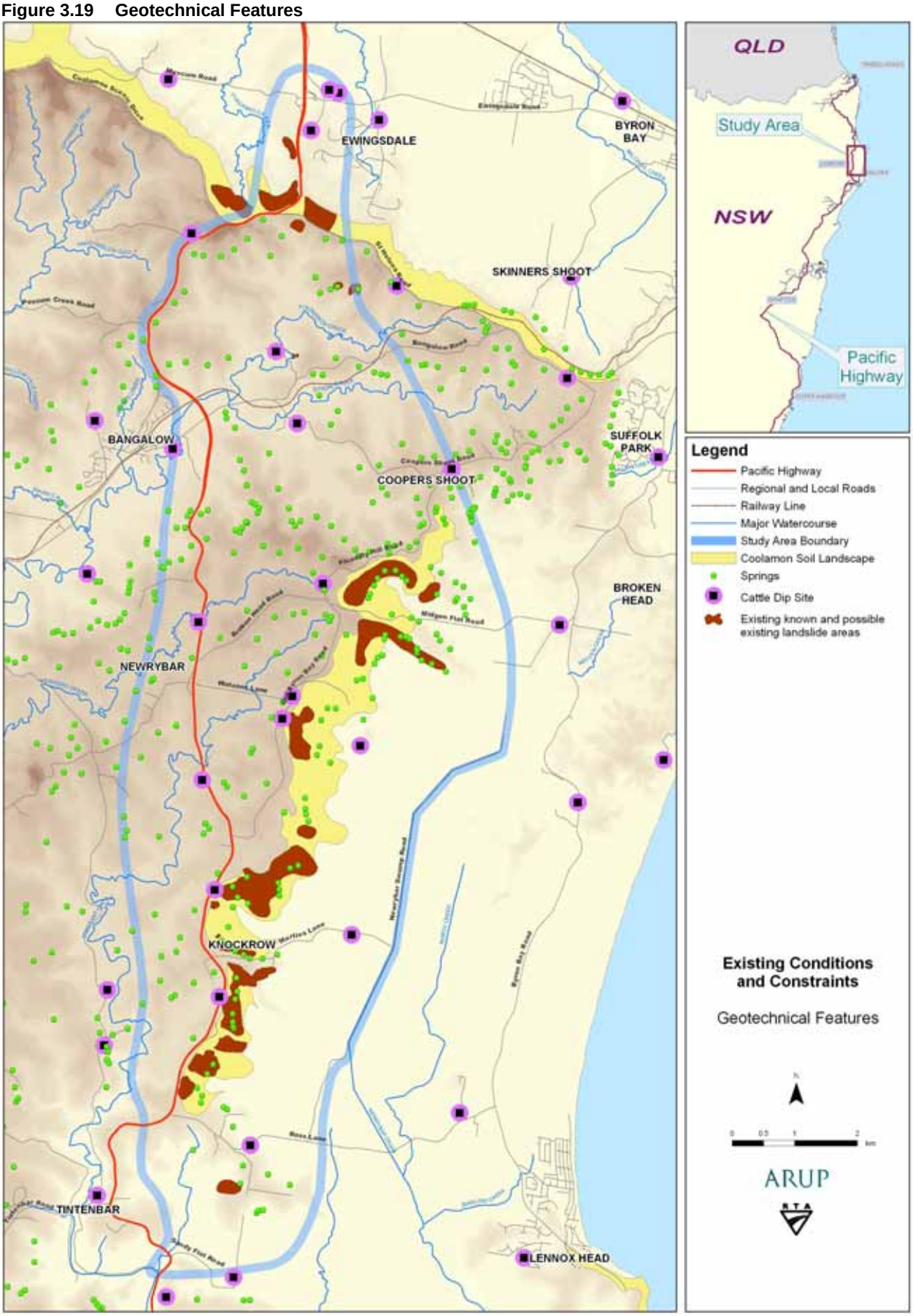
3.14.3 Landslide Hazards

Areas of existing or potential landslides are a constraint to the proposed highway for the following reasons:

- The construction of the new highway may result in remobilisation of existing landslides, or cause instability in other areas which are prone to landsliding.
- Events such as rainfall and seismic activity could remobilize existing landslides or cause new landslides, and adversely impact on the constructed highway.

Areas of known existing or possible existing landslides have been identified as having a high landslide hazard rating and are areas that should be avoided. In the study area, these high landslide hazard rating areas are almost exclusively located in the Coolamon Soil Landscape which should also be avoided where possible, see **Figure 3.19**.

Figure 3.19 Geotechnical Features



3.14.4 Cuts and Construction Material Sources

Cut batter profiles and depths have the potential to impact on visual and aesthetic compatibility (urban design and scenic value), the width of corridor required to construct the road and the balance of cut and fill materials for earthworks. There is also the potential requirement for drill and blast in high and very high strength rock, which may have a noise and vibration impact during the construction phase.

The variable rock conditions mean that different cut batter profiles and excavations techniques would be required depending on the actual conditions at each cut.

There is a high likelihood that drill and blast would be required to excavate competent rock, such as typically occurs in the more elevated parts of the study area. This rock can be excavated to form relatively steep batters (resulting in a narrower road footprint) but may require localised structural support, such as rock bolts, to maintain stability. Where competent basalt overlies poorer quality weathered rock and/or soil horizons, there is a higher risk of instability. This would need to be considered at the design and construction stage.

With some processing and crushing, most of the excavated high strength basalt is expected to be suitable for the production of select materials. In addition, there are some existing operational quarries in or near the investigation area that could supply high quality construction materials.

The relatively low strength rock and residual soil can be excavated using conventional rippers and excavators, with assistance from rock breakers in higher strength layers. The excavated material would be suitable for general embankment fill. Cut batter slopes in low strength rock and residual soils would need to be relatively shallow (max. 2H:1V) and this would result in a relatively wide road corridor.

3.14.5 Tunnel

Geotechnical risks and issues associated with a potential tunnel include tunnel support requirements, potential to impact on the groundwater regime (including local groundwater bores and springs) and excavation methods, which may include drill and blast.

A tunnel beneath St Helena Hill would be designed to go through the Lismore Basalt generally comprising relatively competent high strength basalt separated by more weathered and fractured basalt layers.

The tunnel construction is feasible, using tunnelling techniques that have been used previously in NSW and overseas. Twin tunnels with an arched roof profile and rock pillar separating the tunnels are expected to be suitable for the anticipated ground conditions, similar in profile to the recently constructed Cudgen Road Tunnel. Tunnel excavation would use drill and blast techniques, which offer the greatest flexibility in the anticipated variable conditions.

Aligning the tunnel to avoid poorer rock conditions and locate the arched roof within the competent rock layers would reduce tunnelling risks. This will be considered further in the development of the detailed concept design.

The tunnel is not expected to significantly impact on the existing groundwater regime, and for this reason a drained tunnel option (unlined) is considered feasible. This is because limited groundwater inflows into the tunnel are expected. A tunnel mainly within weathered and fractured rock (roof in competent rock) could be designed so that groundwater inflows are collected and used to supply existing springs in the vicinity of the tunnel portals.

3.14.6 Floodplain

In the floodplain area the road would probably be carried on fill embankments. The key geotechnical issues are the risks associated with the construction of the road over low strength and compressible soils (soft soils); which may impact on the road construction duration, long-term pavement performance, and costs, for construction and long-term pavement maintenance.

The embankments would cause settlement of the compressible foundation soils during construction and also later following completion to design height. The bearing capacity (strength) of the foundation soils would improve as the settlement occurs. The rate of embankment construction (by adding successive fill layers) would need to be carefully balanced so that the strength of the foundation soils is not exceeded and does not result in instability of the embankments during construction. Proven methods are available for increasing the rate of settlement and strength improvement, such as improving the soil drainage and surcharging (temporarily adding a greater height of fill than required). These may have impacts to construction costs and programmes.

Road construction is not expected to impact on the existing groundwater regime beneath Newrybar Floodplain.

Fill embankments on highly compressible soils on the floodplains do settle more than the pile supported bridges. Well proven treatments for bridge approaches would be utilised to manage this issue. These treatments may include pile supported geosynthetic reinforced embankments.

3.14.7 Other Geotechnical Issues

Other geotechnical issues associated with the study area include:

- Halloysitic mineralogy of the residual basaltic clay, which impacts the management of earthworks. These soils are considered suitable for use as general fill material during roadworks provided suitable construction techniques and compaction controls are employed.
- The presence of basalt boulders/corestones in the weathered rock profile, which impacts on excavation techniques.
- Acid Sulfate Soils – Road construction over the floodplain is not expected to result in the release of acid sulfate soils into the environment or changes to the groundwater regime that would result in exposure of potential acid sulfate soils above the water table. Where localised disturbance of acid sulfate soils is required, the works would be carried out in accordance with relatively standard procedures for managing acid sulfate soils, which would be described in an Acid Sulfate Soils Management Plan.
- Contamination – the nature of potential contamination in the study area is typical of a rural agricultural environment with low concentrations of diffuse contamination and some known cattle dip sites (point sources). As the cost of remediating cattle dip sites would be relatively low in comparison to other cost drivers, contamination is not considered to be a criterion for route selection.

3.15 Hydrology and Flooding

This section summarises the existing conditions and constraints identified in the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Hydrology/Hydraulic Working Paper* (RTA 2006). Since the RODR, a flood study, including numerical hydrologic and hydraulic modelling, has been carried out on both the Newrybar flood plain, and the four major creeks on the plateau – Byron Creek, Tinderbox Creek, Skinners Creek and Emigrant Creek. The methodology and outcomes of the flood modelling are summarised in this section.

3.15.1 Study Area Catchments and Creeks

The study area lies predominantly within the catchment of the Richmond River, with the exception of a small section in the far north which forms part of the Brunswick River Catchment. The Richmond River Catchment covers an area of approximately 7,000 square kilometres, from Cape Byron in the north to the coastal plain adjacent to Evans Head in the south and the Border Ranges National Park and the Richmond Range in the west.

There are seven named creeks that pass through the study area. Tyagarah, Tinderbox, Byron, Skinners and Emigrant Creeks originate in the highlands west of the Main Coast Range, and flow generally to the southwest, with the exception of Tyagarah Creek, which flows north to the Brunswick River. The remaining creeks are located in the 'flats' to the east of the Main Coast Range. The area falls wholly within the region overseen by the Northern Rivers Catchment Management Authority. Simpsons Creek, North Creek, Deadmans Creek and the Flood Mitigation Drain are also relevant to characterising the local hydrologic and hydraulic system.

Figure 3.20 shows the major catchment areas and surface water features in the study area.

3.15.2 Flooding Characteristics

Flooding characteristics for the study area have been identified based on review of available contour information, input from the community, site observations, and existing flood mapping held by the Councils and DoNR, as well as numerical hydrologic and hydraulic computer modelling.

Key past reports and plans used to compile hydrologic and hydraulic constraints include:

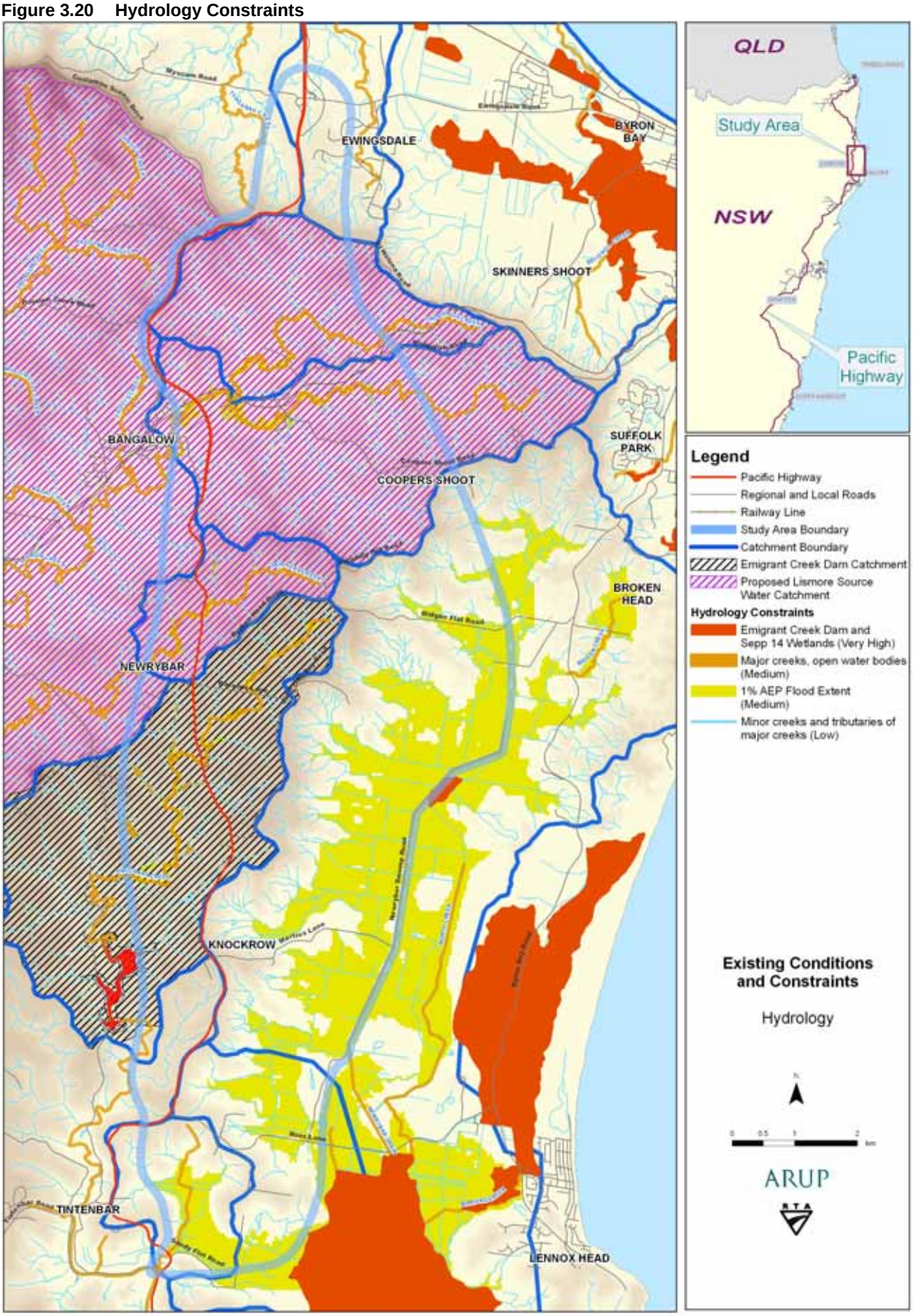
- Ballina Floodplain Management Study (WBM on behalf of Ballina Shire Council, 1998).
- Flood Study of Richmond River Floodplain (DPWS 1991).
- Working Paper on Flooding, Ballina Pacific Highway Bypass EIS (WBM 1998).
- Byron Shire Council DCP Part K: Flood Liable Lands.
- DIPNR (DoNR) floodplain mapping.

The Ballina Floodplain Management Study was carried out in 1996-97, superseding the previous Department of Public Works and Services study carried out in 1991.

The Ballina Floodplain Management model was extended and used for the assessment of the Ballina Bypass, and has been further extended northwards to incorporate the relevant catchments for the floodplain of the Tintenbar to Ewingsdale project. This study has been carried out since the RODR and is described below.

Hydrologic and hydraulic modelling has also been completed for the four major creeks on the plateau, namely Byron Creek, Tinderbox Creek, Skinners Creek and Emigrant Creek. The results of this modelling are also discussed in **Section 3.15.3**.

Figure 3.20 Hydrology Constraints



3.15.3 Newrybar Floodplain Study

The flood study has identified and modelled design floods comprising combinations of the three primary sources of flooding:

- Rainfall over the Richmond River Catchment (total catchment area 7,000 km²) causing the river to swell and break its banks.
- Rainfall on the local catchments and floodplains (Maguires Creek, Emigrant Creek, North Creek etc).
- Elevated ocean levels and storm wave conditions.

The hydrologic modelling indicates that the 12 hour storm event is generally the critical event (generating the peak flows) in the local catchments, with the 9 hour storm giving slightly higher peaks in some of the smaller catchments. Richmond River dominated flooding has a 72 hour critical duration.

The output from the hydrologic modelling is a series of flow hydrographs at selected locations, which are used to simulate the passage of the flood down local creeks and over the floodplains.

The extended hydraulic model includes one-dimensional elements for the Richmond River from the Broadwater to its mouth; Maguires and Emigrant Creeks as local catchments; and a two-dimensional floodplain grid encompassing North Creek, Deadmans Creek and Sandy Flat Creek. The flood model was verified against reports of historical flood events received from the RTA, other agencies and the community, and by checking flow vectors to ensure that they are generally parallel to crop rows, as identified from aerial photography. Results were consistent with reported flooding and with farming practice.

The flood extents for the 1% Annual Exceedance Probability (AEP) flood event, classified as a 'medium' constraint, are shown in **Figure 3.20**. The area of influence of the Richmond River is in the lower North Creek area, predominantly centred on Ballina Nature Reserve and South. The balance levels are influenced predominantly by the local catchment runoff or 12 hour storm event. The ocean storm tide dominated flooding occurs only in small pockets at the escarpment/floodplain seam producing flood levels only marginally higher than local catchment dominated flooding. As the Richmond River area of influence is removed from the Route Options, local catchment flooding can therefore be used to define baseline conditions.

Flood modelling for the existing 1%, 5% and 20% AEP local catchment flood events has been undertaken. **Figure 3.21**, **Figure 3.22**, and **Figure 3.23** demonstrate the baseline flood behaviour in the 1% AEP Event.

Figure 3.21 Hydraulic Model Results - Baseline 1% AEP Peak Flood Level (mAHD)

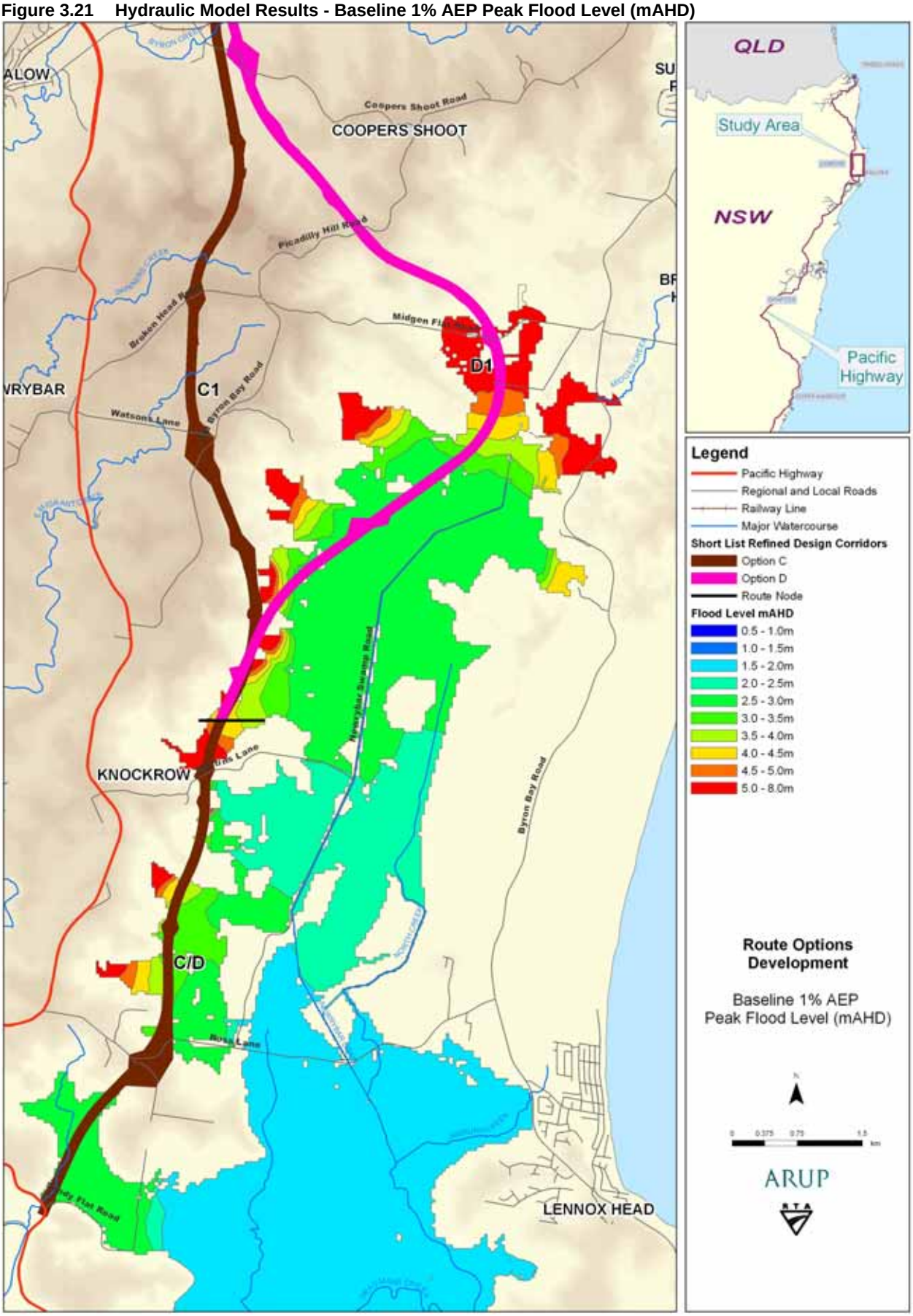


Figure 3.22 Hydraulic Model Results - Baseline 1% AEP Peak Flood Depth (m)

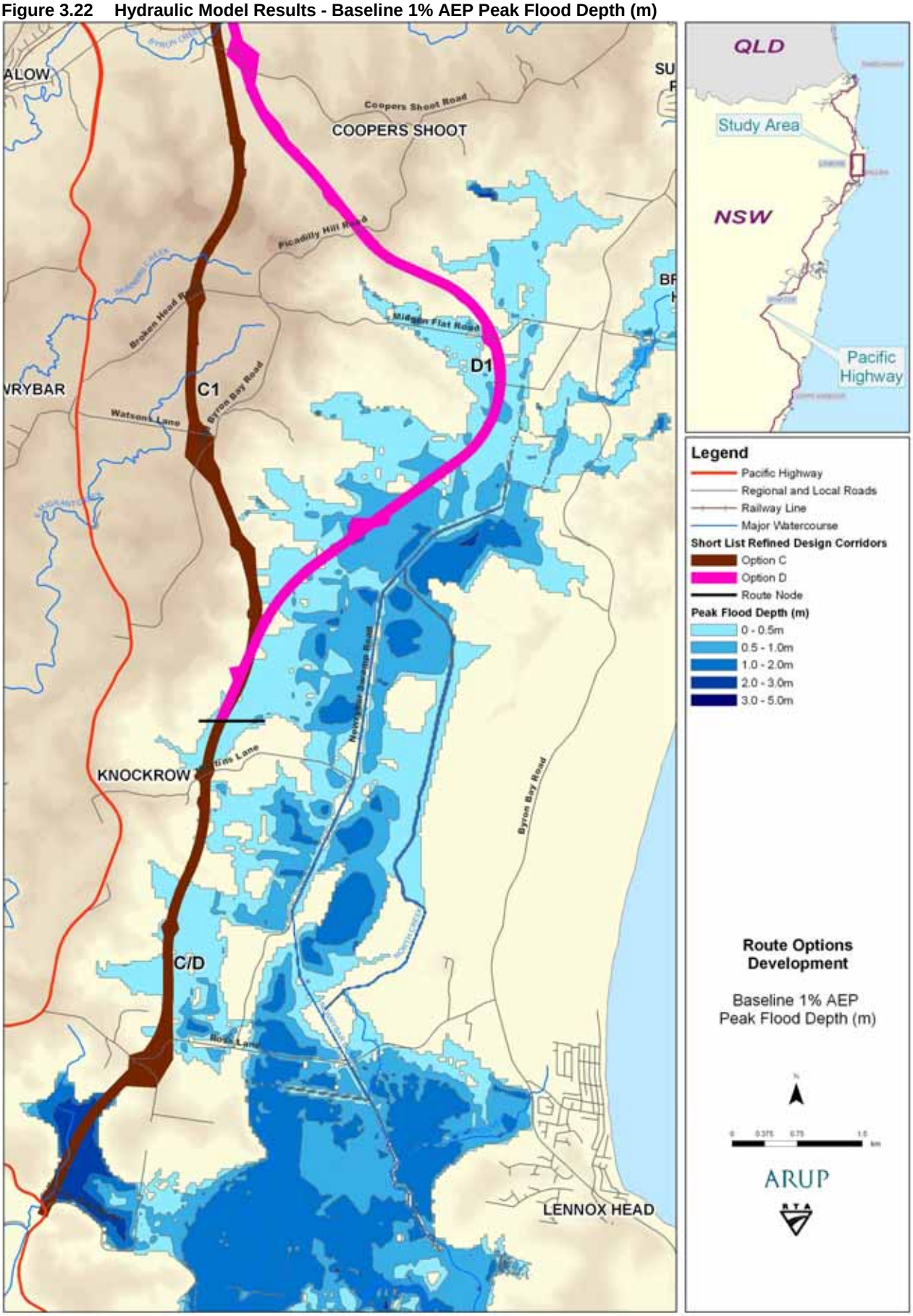
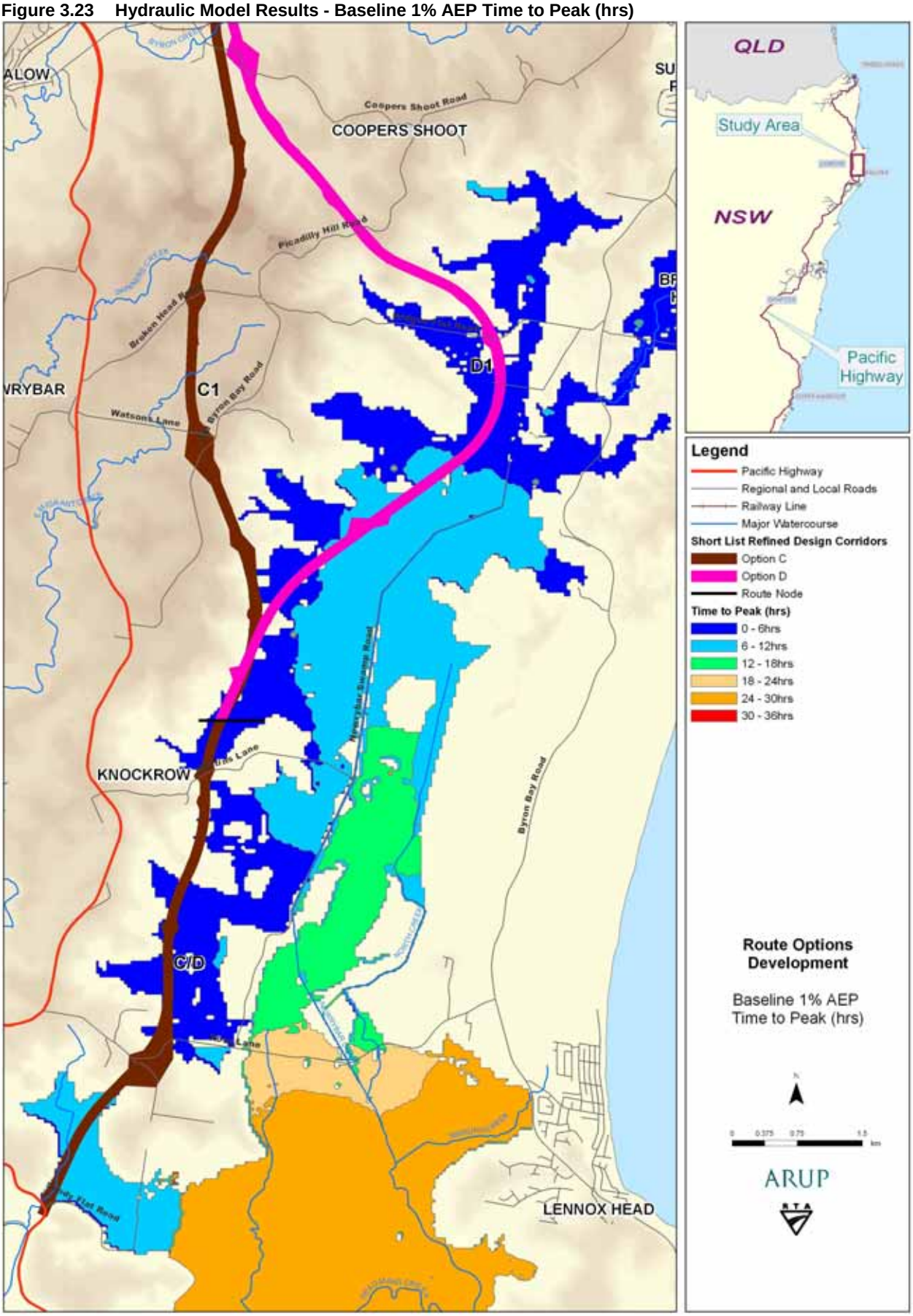


Figure 3.23 Hydraulic Model Results - Baseline 1% AEP Time to Peak (hrs)



Study of Flooding on the Plateau

The peak storm event for the four major creeks on the plateau has been found to be the 24 hour duration storm. The peak flow for each of the major creeks on the plateau associated with the 1% AEP flood event is shown in **Table 3.14**.

Table 3.14 Flow at Key Locations in the Four Major Plateau Creeks

Creek	Location	Flow (m3/s)
Byron	Location of existing Pacific Highway crossing creek	532
	Just before Tinderbox/Byron Junction	251
	Just after Tinderbox/Byron Junction	506
	Downstream Extent of Study Area	595
Tinderbox	Location of existing Pacific Highway crossing creek	NA
	Just before Tinderbox/Byron Junction	246
Skinners	Location of existing Pacific Highway crossing creek	68
	Downstream extent of study area	116
Emigrant	Location of existing Pacific Highway crossing creek	146
	Downstream extent of study area	258

The resulting water surface profile was overlaid on the digital terrain model to establish the outer limits of the 1% AEP flood event. These flood extents were then incorporated into the constraints mapping for the study area, as shown in **Figure 3.20**.

Drainage and Structures

The modelling was used to determine the required number and length of cross drainage structures required to ensure that the upgrade would remain open to traffic in a 100-year average recurrence interval flood, and that the highway upgrade embankment would not cause unacceptable increases in flood levels or duration.

Waterway opening requirements and bridge locations and lengths have also been reviewed and refined for all options. The revised drainage and other waterway and access road structures are included in the amended cost estimates for each shortlisted route option.

Constraints

The constraint levels of hydrological issues mapped in **Figure 3.20** are defined below in **Table 3.15**. For the purpose of this study, all named creeks identified on topographic mapping have been defined as major creeks, with the remaining watercourses categorised as minor creeks. All creeks within the area of investigation are relatively small in real terms.

Table 3.15 Constraint Levels

Constraint Classification	Description
Very high	Wetlands that are subject to *State Environmental Planning Policy No. 14 – Coastal Wetlands*. No very high hydrologic constraints have been identified within the study area.
High	Major river systems. No high hydrologic constraints have been identified within the study area.
Medium	Major creeks, locations of creek confluence, open water bodies, potential flood prone areas.
Low	Minor creeks and tributaries of major creeks.

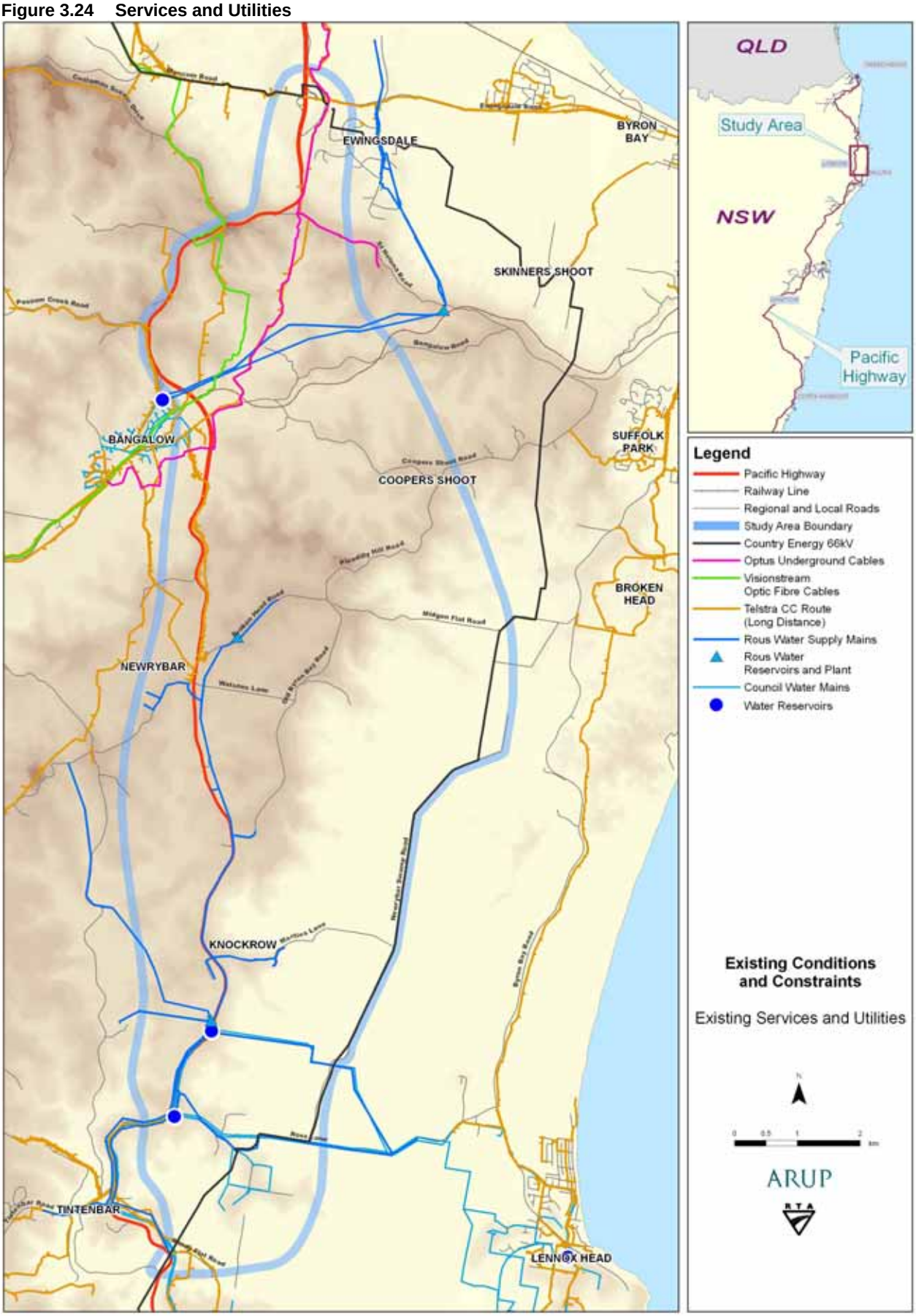
3.16 Public Utilities

Utilities identified in the study area are listed below and shown in **Figure 3.24**:

- Telstra fibre optic cables beside the existing highway. Telstra copper cabling of varying sizes can be found throughout the study area, servicing residences and commercial facilities.
- Visionstream fibre optic cables from Bangalow to Ewingsdale. These follow Bangalow Road from the west, then through the north of Bangalow crossing the existing highway in the vicinity of Byron Creek before heading north primarily along property boundaries, east of the existing highway corridor. The cables then approach the existing highway opposite Coolamon Scenic Drive and travel parallel to the highway before crossing at Fowlers Lane and travelling parallel to the highway back to Coolamon Scenic Drive before heading west along Coolamon Scenic Drive.
- Optus fibre optic cables along St Helena Road and from Ewingsdale to Bangalow, east of the existing highway corridor. These cables extend north from Ewingsdale towards Tyagarah on the eastern side of the highway as well as west towards Lismore on the southern side of Bangalow Road.
- Rous Water 600 mm diameter trunk water supply mains from Emigrant Creek Dam and Rocky Creek Dam to Bangalow, Knockrow treatment plant and reservoir and distribution watermains to the north and south. The components of these distribution mains include sections:
  - Following the existing highway south to Tintenbar.
  - Heading east from Knockrow along existing property boundaries then south along Newrybar Swamp Road, before heading west along Ross Lane and connecting with the southern highway main (above).
  - Heading north along the existing highway, then to the east of the highway until Broken Head Road where it heads east to a reservoir and continuing a short distance east along Broken Head Road.
  - Rous Water also has distribution mains connecting to a Council reservoir on the northern side of Bangalow, heading east and crossing the existing highway, travelling approximately parallel to Bangalow Road, to a reservoir on St Helena Road before heading north-west to Ewingsdale.

- Ballina Shire Council water supply mains beside the existing highway south of Knockrow, as well as Ross Lane and Newrybar in the vicinity of the Rous Water supply mains described above.
- Country Energy power supply infrastructure, including a 66 kV supply line which crosses the existing highway at Sandy Flat Road before heading north-east to Ross Lane near the intersection with Sandy Flat Road. From this point the supply line follows Ross Lane before heading north along Newrybar Swamp Road on the eastern edge of the study area, then further north outside the study area to Skinner Shoot and north-west to Ewingsdale.

Figure 3.24 Services and Utilities



Modifications and Refinements to the Concept Design of the Short List of Route Options

In addition to the investigations previously described, the Project Team conducted a review of comments and submissions arising from the public display and the VMW, and re-examined the alignments of the short list of route options as presented in the RODR. This section describes: modifications that have been made to the alignments of the short list of route options; creation of subsections for A1 and B1; footprint design refinements including consideration of local access arrangements; and comparative cost estimates.

3.17 Alignment Modifications to the Short List of Route Options

As a result of the reviews and additional studies undertaken since the RODR, there have been some minor modifications to the short list of route options. Most modifications result in the options remaining within the 250 m wide corridor shown in the RODR. Areas where modifications resulted in an adjustment of the 250 m wide corridor are described below. The modified alignments shown in **Figure 3.25**, **Figure 3.26** and **Figure 3.27** reflect refined design corridors as described in **Section 3.18**.

3.17.1 Modification to Section A1

The alignment was shifted closer to the existing highway adjacent to Knockrow to reduce agricultural impacts and to reduce the impact on a spring fed stream. Two 750 m radius curves were introduced to move the upgraded highway to the east side of Martins Lane West and to move the alignment to the east of an unnamed creek. This shift moves part of Section A1 slightly outside the 250 m corridor included in the RODR as shown in **Figure 3.25**.

3.17.2 Modification to Section B1

On Section B1 between Knockrow and Newrybar, there are a number of major constraints including topographical features, closeness to Emigrant Creek, high value agricultural properties, residential dwellings and businesses.

While the shortlisted route option between Knockrow and Newrybar provides a good balance between all these issues, it was considered that the route option could be further improved by shifting a short length of this alignment further away from Emigrant Creek and closer to the existing highway. This minor modification would reduce construction risks in the area of Emigrant Creek.

This modification moves part of Section B1 slightly outside the 250 m corridor included in the RODR as shown in **Figure 3.26.**

3.17.3 Modifications to Section C/D and D1

Section C/D was shifted west at Martins Lane to reduce environmental, geological and social impacts. The shift moves part of the alignment beyond the western edge of the 250 m corridor included in the RODR as shown in **Figure 3.27**.

Additionally, Section D1 was shifted slightly to the east in order that the alignment further north could avoid a high value environmental constraint. This shift moves part of the alignment beyond the eastern edge of the 250m corridor included in the RODR as shown in **Figure 3.27.**

Figure 3.25 Modification to Section A1

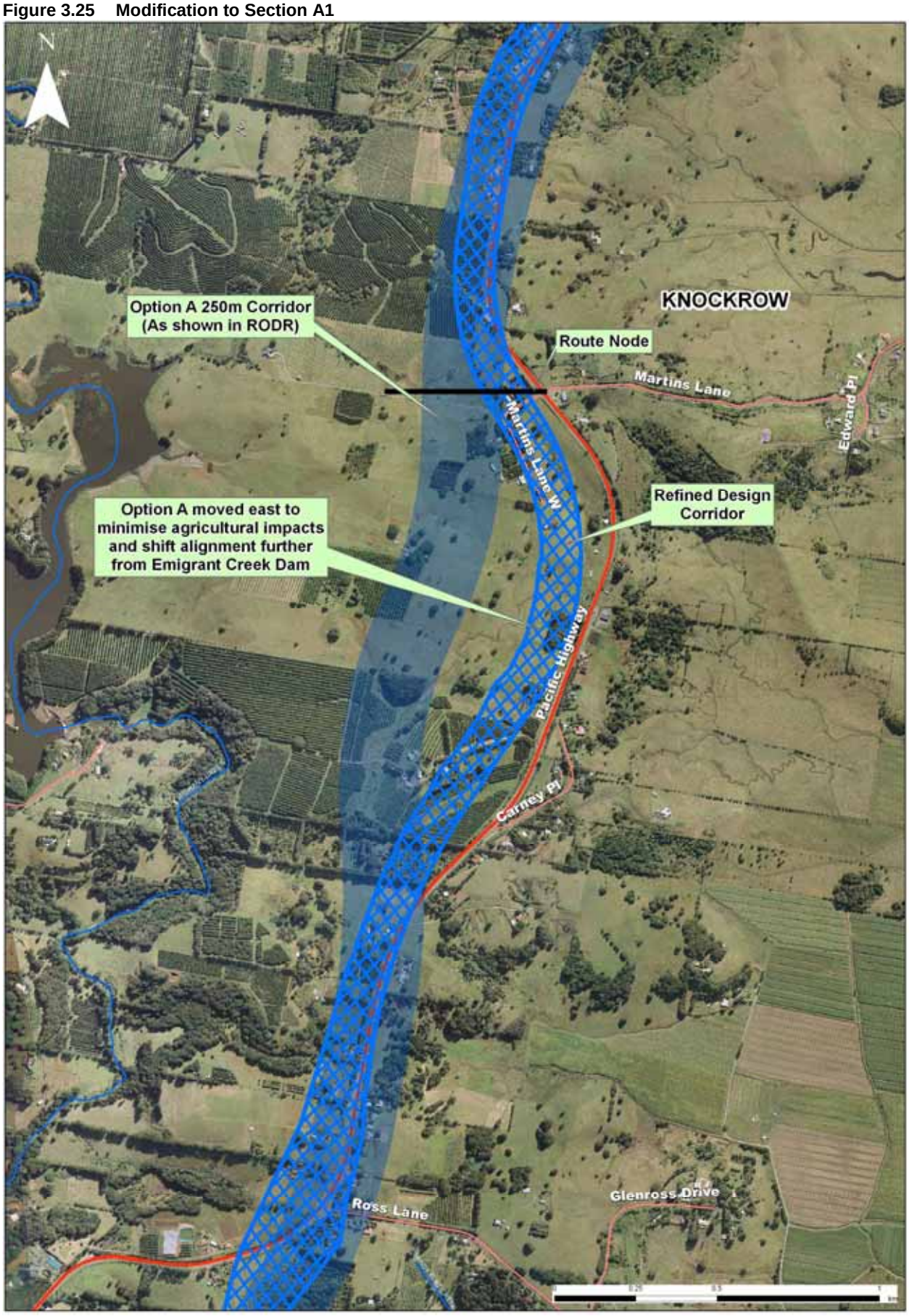


Figure 3.26 Modification to Section B1

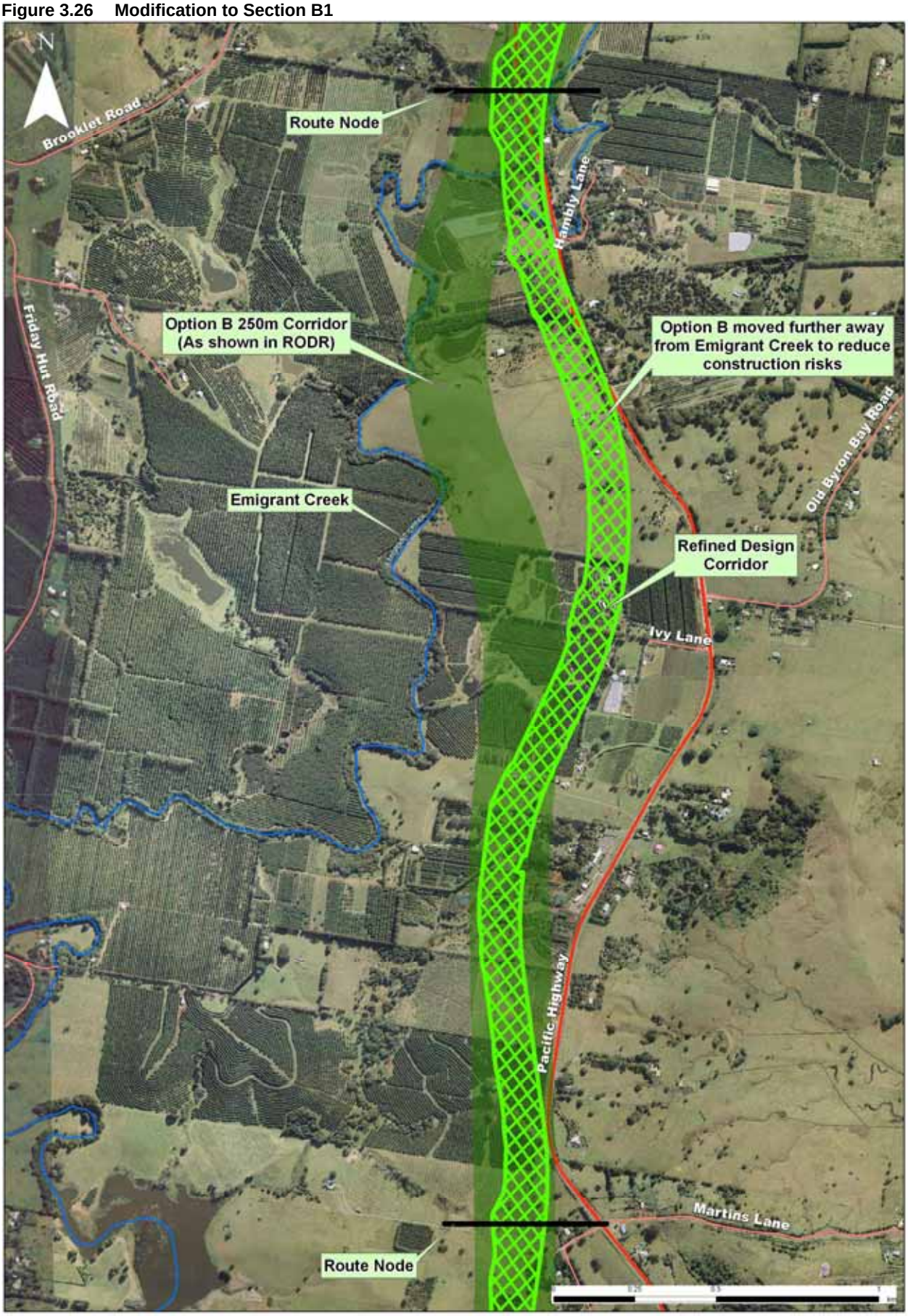
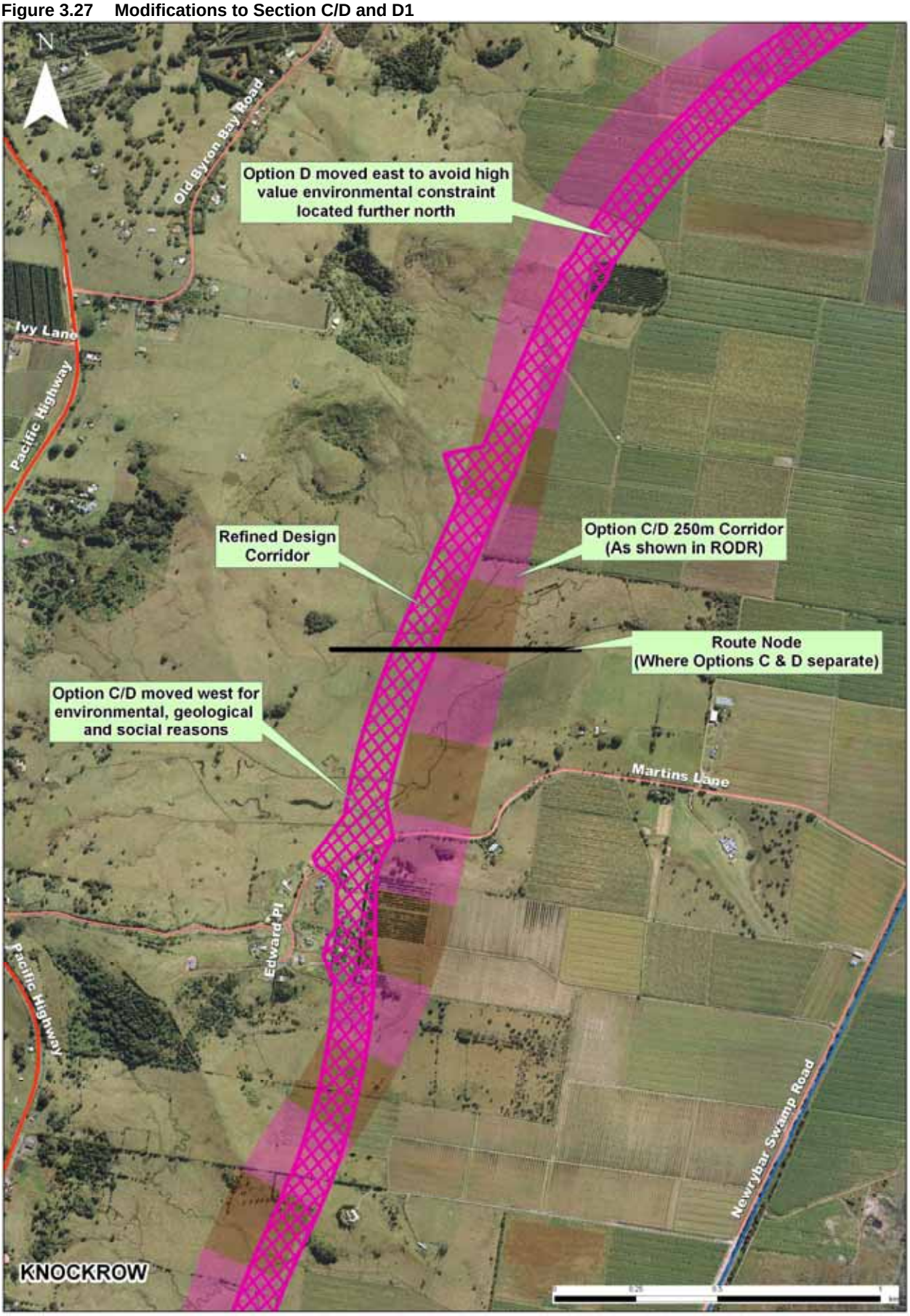


Figure 3.27 Modifications to Section C/D and D1



3.18 Subsections of A1 and B1

Sections A1 and B1 cross each other at Knockrow and just south of Newrybar. Where these sections cross there are opportunities to interchange segments of Section A1 and B1. In order to conduct a detailed assessment of the possible combinations of Sections A1 and B1, three subsections for both A1 and B1, namely A1-a, A1-b and A1-c and B1-a, B1-b and B1-c were created. These subsections, based on the refined design corridors, are shown in **Figure 3.28**.

Combinations of the sections and subsections are assessed in **Chapter 6** as part of the process of selecting the preferred route. Assessment of these subsections also responds to one of the outcomes of the VMW (see **Chapter 5**).

3.19 Refined Design Corridors

After making the alignment refinements to the draft concept designs, the 250 m route option corridors presented in the RODR were further developed and the extent of cut and fill earthworks were identified for each section of the shortlisted route options – resulting in preliminary concept designs for the shortlisted route options. The footprint for the preliminary concept design includes allowances for new frontage roads and diversion roads required to maintain local access. The footprint also includes a margin for drainage or other works that may be required beyond the extent of the earthworks and is based on the preliminary concept design.

The comparative analysis of the short list of route options included in **Chapter 6** is based on the design footprint. Route option alignments shown in figures in this chapter are classified as 'refined design corridors', not footprints. These corridors allow a margin for future design refinement. The refined design corridors for the shortlisted route options are shown in **Figure 3.29** and **Figure 3.30**.

3.19.1 Local Road Network and Local Access

If the upgraded highway is on a new alignment then the existing highway could be retained as a separate local road network and grade separation would be provided wherever the upgraded highway crosses the existing highway. For cost reasons the number of these crossings should be kept to a minimum and the vertical alignment of the upgraded highway should be developed considering vertical clearance requirements.

Grade separation would also generally be required where the upgraded highway crosses the main local access roads, unless suitable alternative local access arrangements could be made. Local roads likely to require grade separation include Ross Lane, Martins Lane east and west, Old Byron Bay Road, Watsons Lane, Brooklet Road, Broken Head Road, Lawlers Road, Coopers Shoot Road, Bangalow Road and St Helena Road. As above, the number of locations where the upgraded highway crosses the local roads should be kept to a minimum and the vertical alignment of the upgraded highway should be developed considering vertical clearance requirements.

All options provide alternative access arrangements to the local road network where the only existing access to a property is affected by the route option. Proposals for local access have been developed for each shortlisted route option (see **Figure 3.31, Figure 3.32**, **Figure 3.33** and **Figure 3.34**). Traffic flows predicted for the short list of route options are also provided. These figures show Options A and B with the T1 tunnel and Options C and D with the T2 tunnel in order to show the differences in the local access arrangements with the two tunnel options. Either tunnel option can be matched with any route option.

Figure 3.28 Subsections of A1 and B1

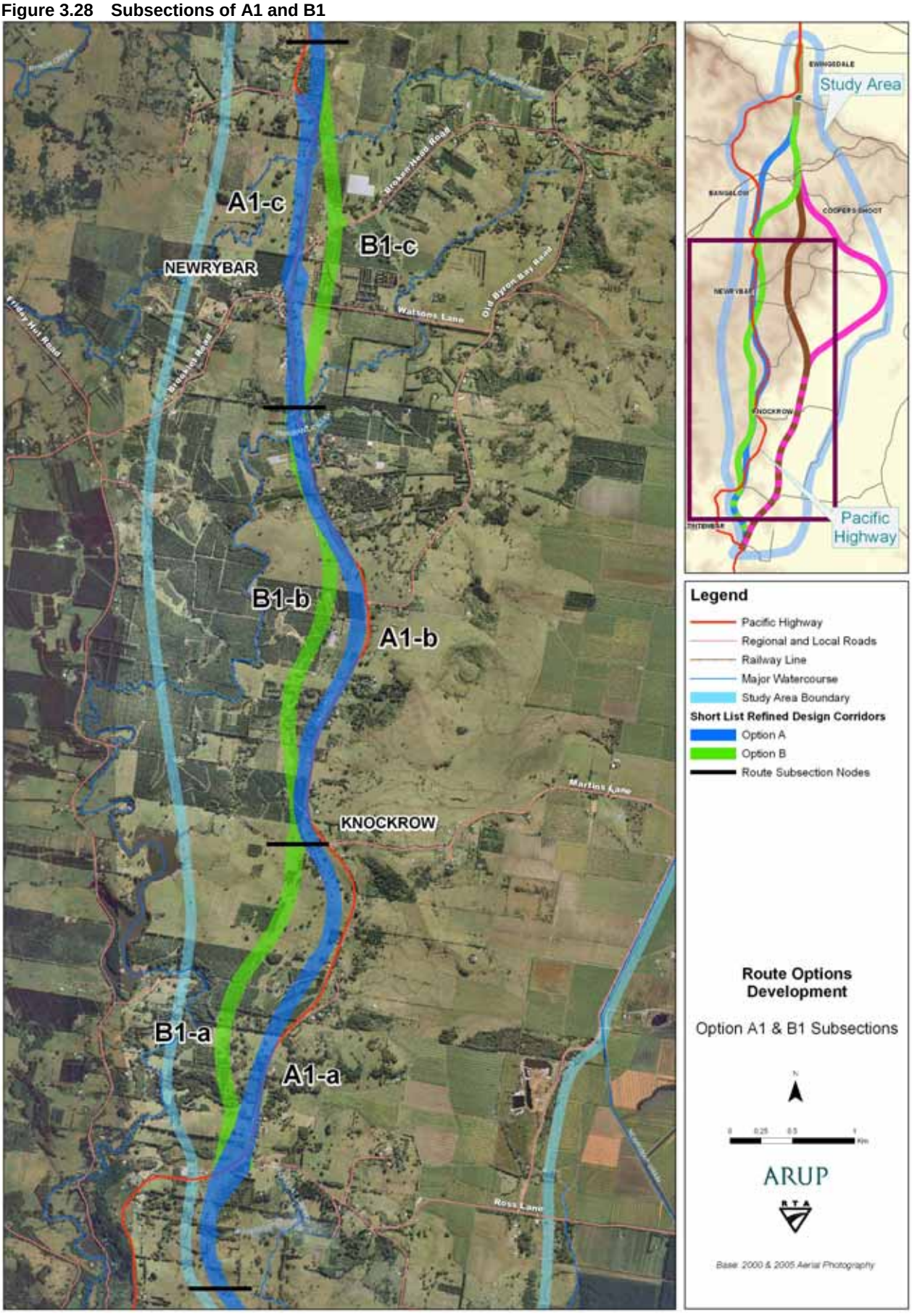


Figure 3.29 Refined Design Corridors for Options A and C

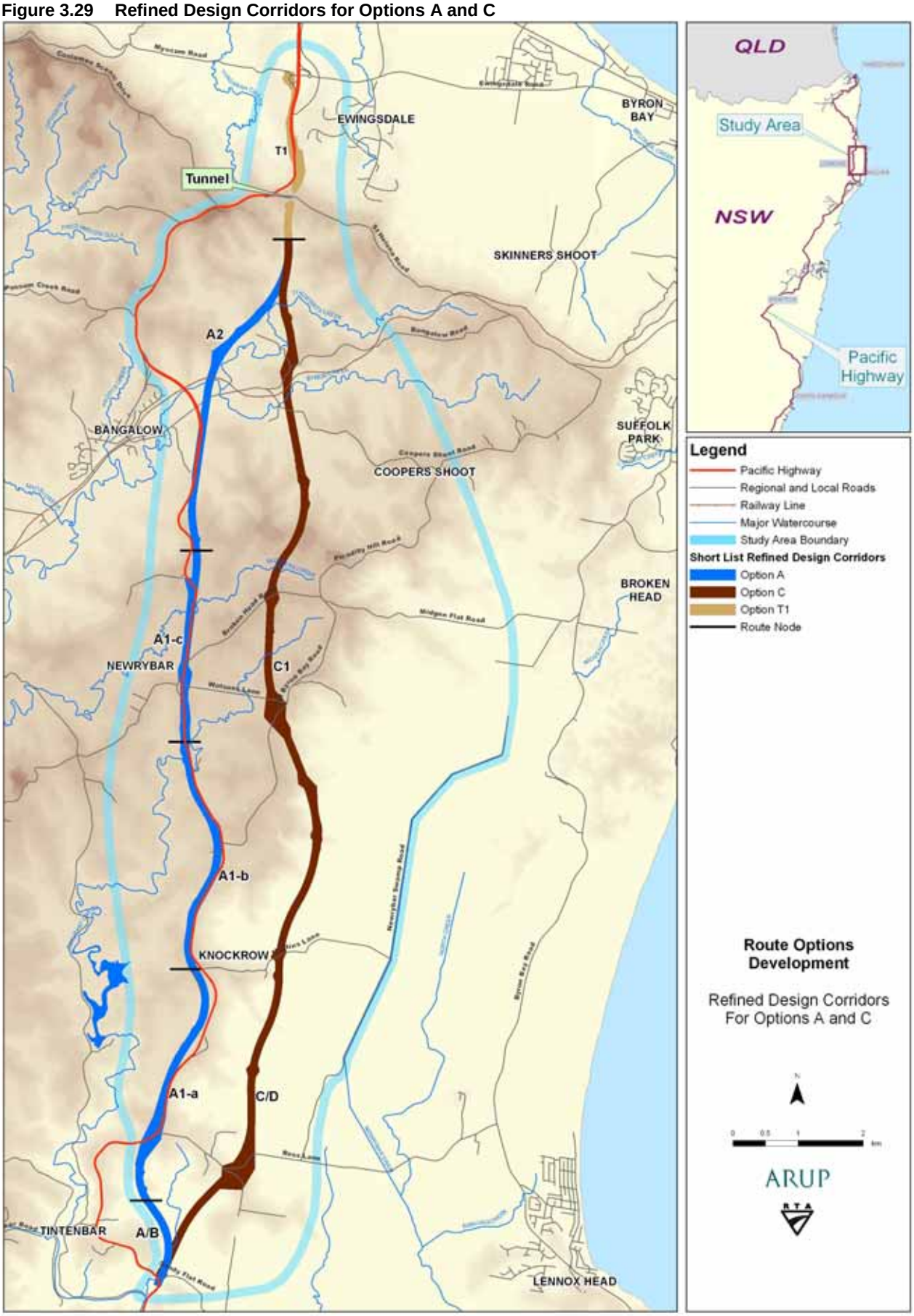


Figure 3.30 Refined Design Corridors for Options B and D

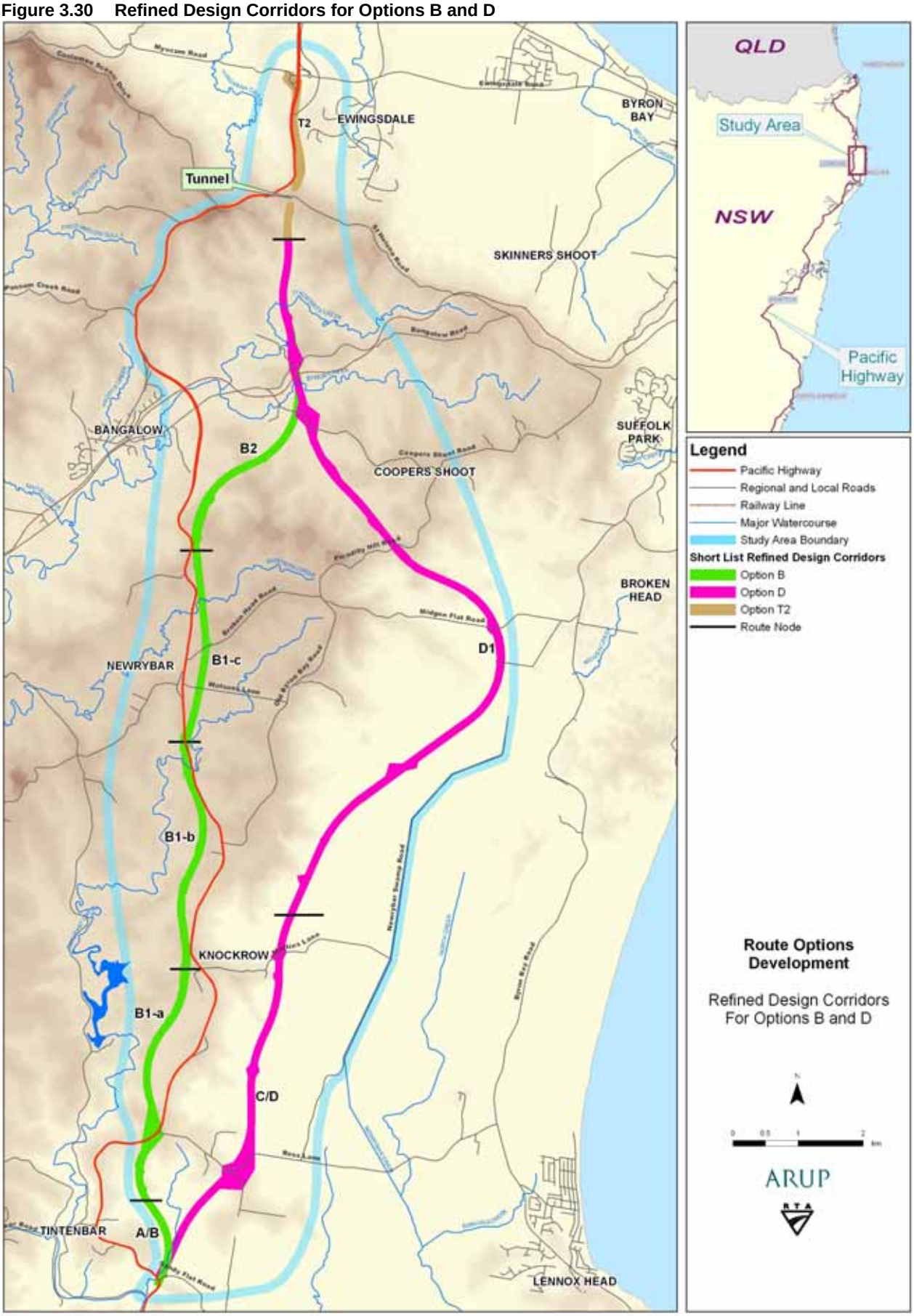


Figure 3.31 Option A Local Road Network

Figure 3.32 Option B Local Road Network

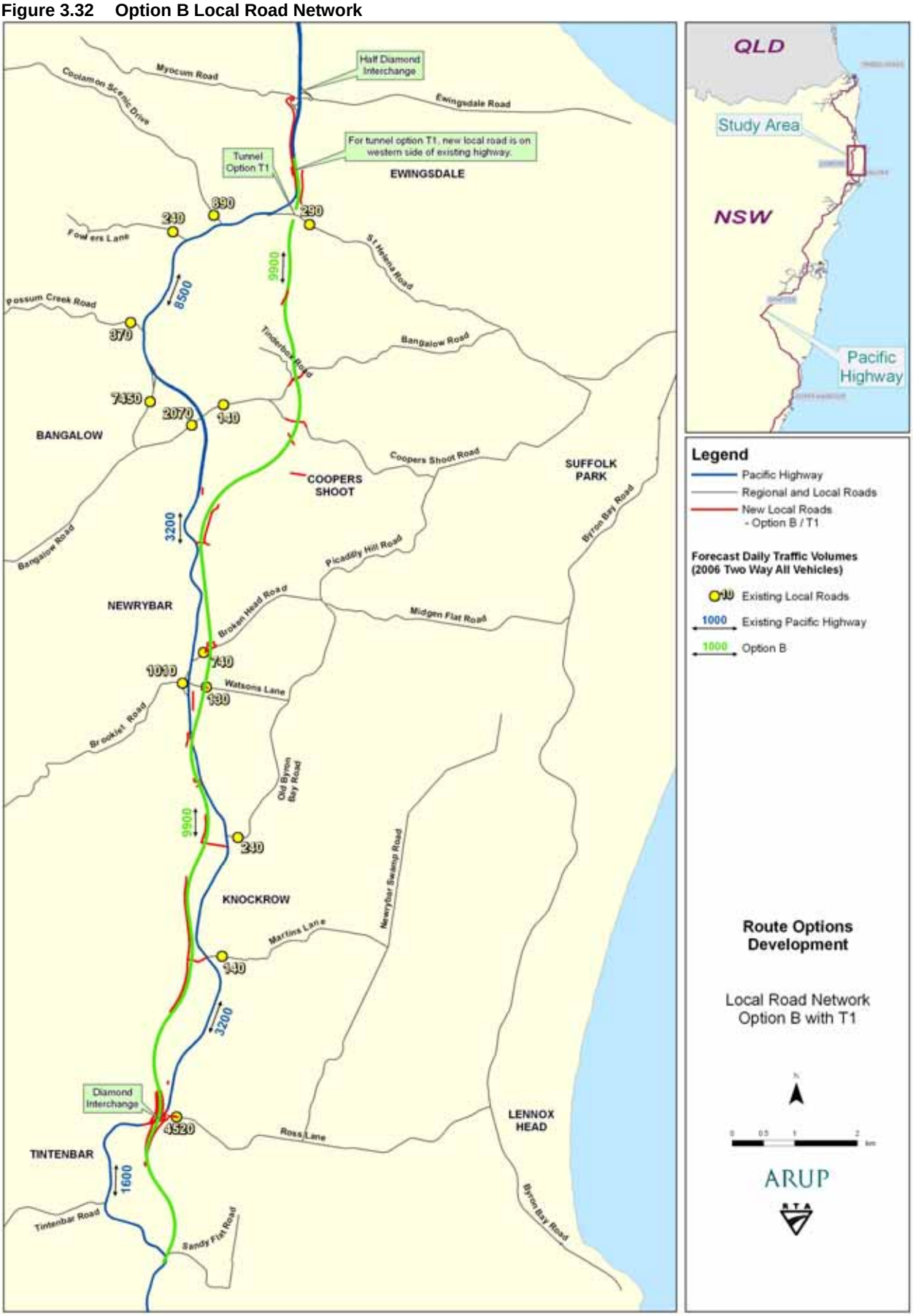


Figure 3.33 Option C Local Road Network

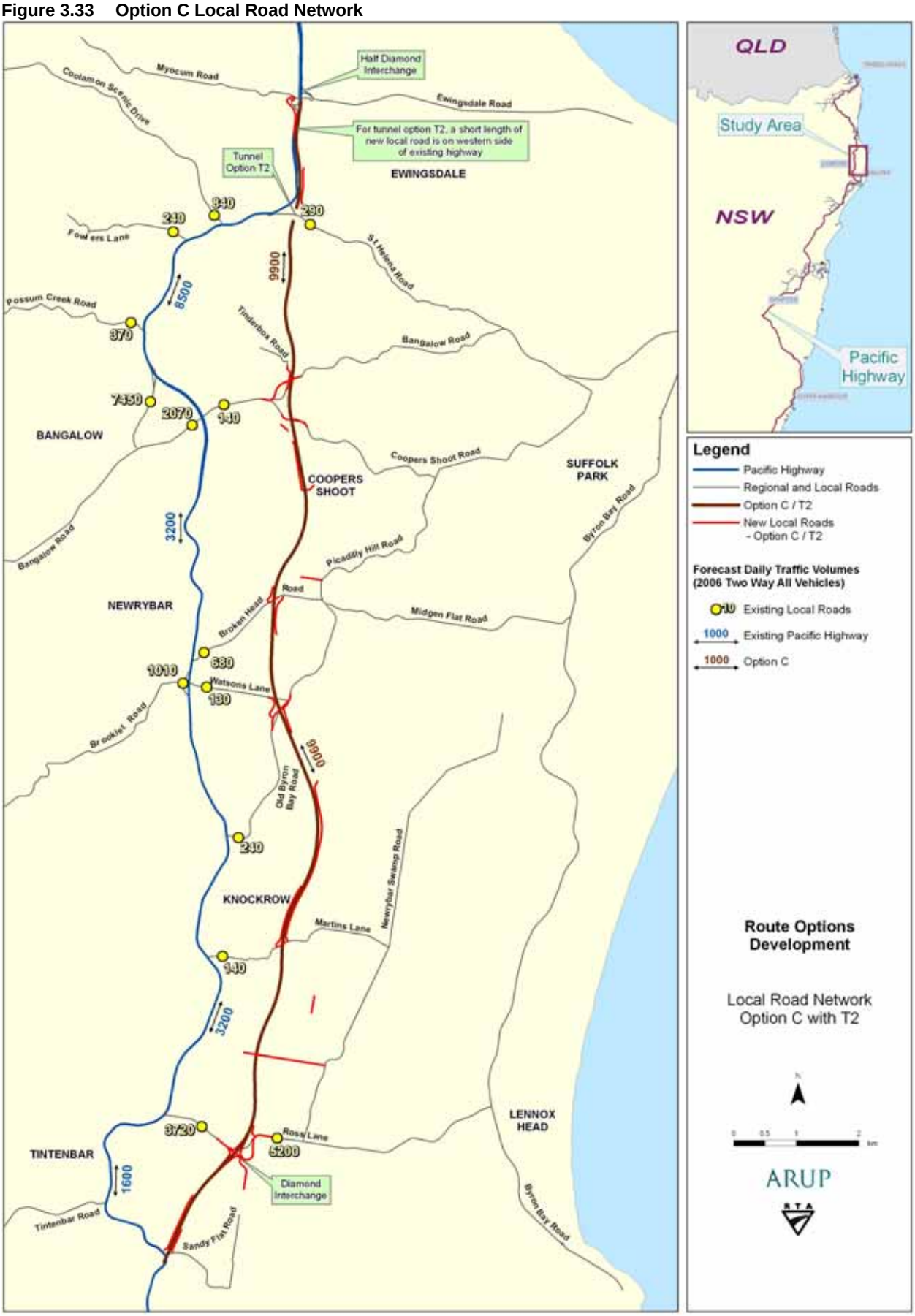
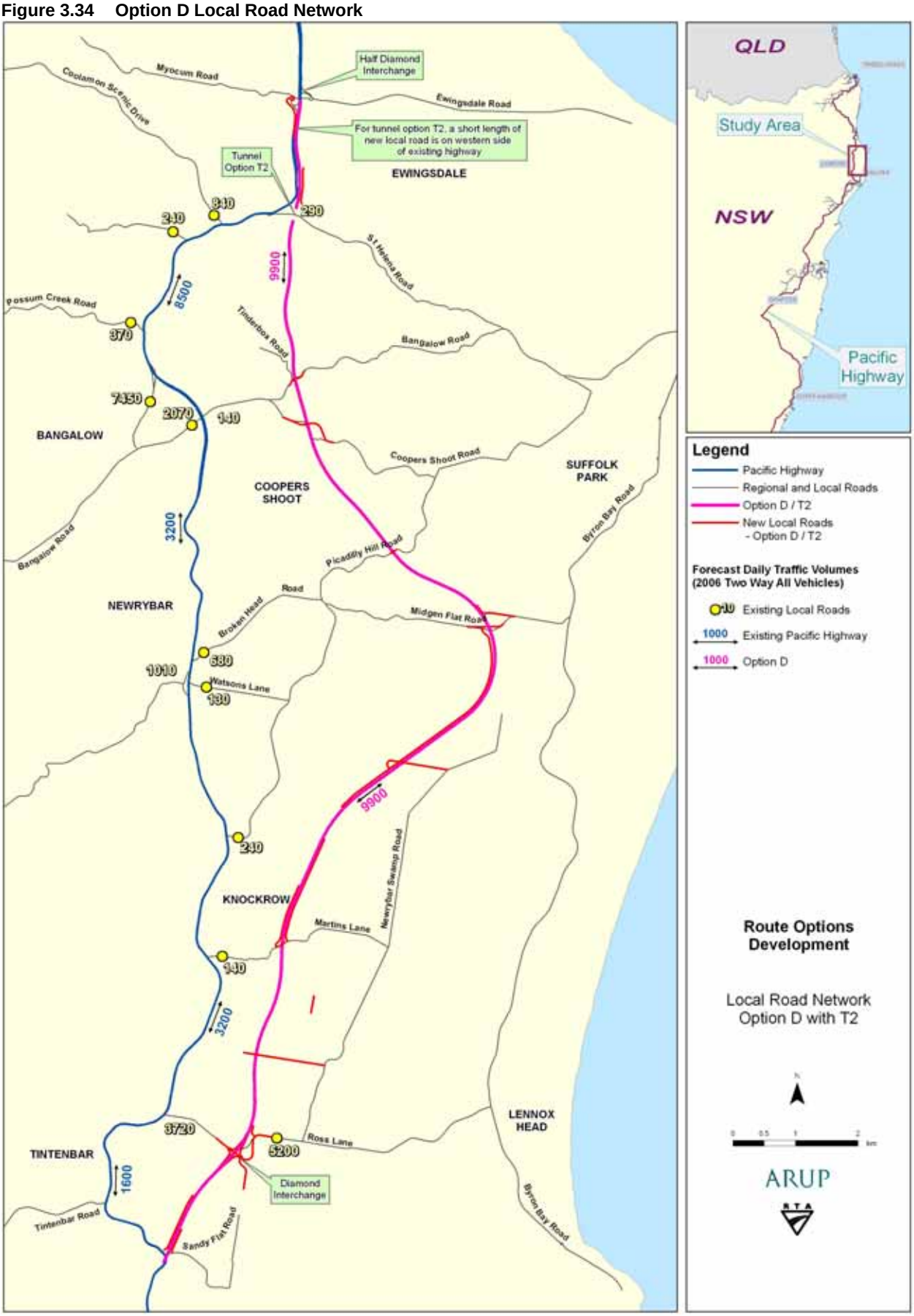


Figure 3.34 Option D Local Road Network



3.20 Comparative Cost Estimates

3.20.1 Approach

Comparative cost estimates have been prepared in accordance with the RTA's *Project Management Guidelines for Estimating, Scope and Cost Control for Development Projects* (Version 3, RTA 2000). The estimates are based on typical construction contract rates and on quantities derived from the draft concept design of the short listed route options.

Since the strategic cost estimates were prepared as part of the RODR, comparative cost estimates have been prepared. A greater level of design detail has now been applied to each of the short listed route options and the earlier estimates have been revised and updated to reflect the following:

- Design adjustments as necessary to accommodate the findings of additional engineering and environmental surveys, including in particular the flood studies and additional geotechnical investigations.
- Design adjustments have been made where appropriate to reflect submissions received following the route options display as well as the results of numerous landowner meetings held during and subsequent to the display.
- Cut and fill batter slopes have been adjusted to reflect the findings of the additional geotechnical investigations, and earthworks extents and volumes have been amended accordingly.
- Road levels have been adjusted to reflect the flood modelling and ensure that the options would remain open to traffic in a 100 year rainfall event.
- Detailed proposals for local access have been developed for each short listed route option.
- Structure requirements have been developed based on local access, geotechnical and flood passage requirements as derived from the flood modelling.
- Preliminary drainage designs have been completed for cross-drainage and culvert quantities estimated according to size and length.
- Construction costs have been updated to March 2006 costs and unit rates for major items have been adjusted in accordance with recent RTA advice on typical construction costs for the Pacific Highway upgrades.

Following agreement on the scope and extent of design modifications to the shortlisted route options, comparative cost estimates in March 2006 dollars have been prepared for each possible combination of the shortlisted route option sections. Including the T1 and T2 tunnel options, there are 36 possible route combinations.

3.20.2 Scope Definition

Each of the route options extends from Sandy Flat Road in the south to Ewingsdale interchange in the north. The broad scope of work applicable to all route options includes:

- Class M standard, 110 km/h posted speed limit, controlled access with no at-grade intersections.
- Two lanes in each direction with a 12 m wide median which allows for the addition of a third lane in each direction.
- Carriageway width of 11.5 m wide at bridges and tunnel to allow addition of third lane in each direction without widening of structures. This width assumes that when the third lane is added, cyclists would be diverted onto the existing highway as an alternative route.
- Diversion or grade separation where local roads cross the proposed highway.

- No intermediate interchanges between the proposed Ross Lane interchange at Sandy Flat and the existing interchange at Ewingsdale.
- Separation of local and through traffic by provision of a separate road for local traffic, generally the existing highway. North of Bangalow the existing highway would be retained as a link between Lismore/Bangalow and the north, with access provided to the highway at Ewingsdale interchange.
- Modifications to the Ewingsdale interchange to allow separation of through traffic to the south from local traffic destined for Bangalow/ and locations west from Bangalow.
- A tunnel through St Helena Hill, approximately 250 m long.
- Upgraded highway designed for B-Double usage but not local road connections since none of the local roads are designated for B-Double usage.

3.20.3 Structure of Comparative Cost Estimates

Cost estimates for each option are in the standard RTA format that divides the project into six major cost components as follows:

1. Project development (includes costs up to and including planning approval).
2. Investigation and design (includes design and documentation of the approved project for construction).
3. Property acquisition.
4. Public utility adjustments.
5. Construction (the main elements are earthworks, pavements, structures and drainage; separate allowances are made for environmental works, site management, RTA representation etc).
6. Handover (includes costs associated with project completion and handover of completed assets to the relevant authority).

The items included under each component are further described in the following sections. All costs include RTA project management and technical review costs.

3.20.4 Project Development Costs

These costs include activities in the option investigation, concept design and design development and approval phases of the project.

Allowance has been made for costs to date plus an allowance for costs through to project approval including:

- Engineering concept design of the preferred route.
- Geotechnical investigation of the preferred route.
- Environmental assessment of the preferred route.
- Topographical survey of the preferred route.
- Technical input from the Project Team and environmental assessment of the preferred route.
- Advice from other government agencies.
- Preparation of Submissions Report.
- Preparation of project estimate.

3.20.5 Detailed Investigation and Design Costs

These costs normally include all activities in the detailed design and implementation phase between the end of the design development and approval phase and commencement of tendering (with the exception of property acquisitions and public utilities). In this instance it is likely that most of these activities would occur following the appointment of a consortium/contractor for the project.

Detailed design and investigation costs would include:

- Geotechnical investigations.
- Final topographic survey for final design.
- Hydraulic and hydrological studies.
- Fauna and flora impact studies.
- Advice from other government agencies.
- Utilities locations and searches.
- Detailed project design and design review.
- Technical input from the Project Team.
- Preparation of project environmental plans.
- Preparation of bid documents.
- Safety audits.
- Detailed estimate preparation.

3.20.6 Property Acquisition Costs

Property acquisition costs have been estimated using the results described in *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Woking Paper on Agricultural Considerations for Route Options* (RTA 2006). This report includes an assessment of the worth of land affected by the shortlisted route options, including rural residential properties. The assessment included allowance for the effects of severance on property worth. It was carried out on a lot by lot basis and reflected the base value of the land plus allowances for agricultural improvements (to allow for the costs associated with establishing the various agricultural enterprises). It should be noted that actual acquisition costs will differ from average figures used, and will be dependent on individual property issues.

The purpose of the report was primarily to allow a comparison of the impacts of the shortlisted route options on agriculture, but it is based on recent sales in the area and provides a guide to likely acquisition costs. The estimates make no allowances for compensation or for future changes in value of the land, and higher than normal contingencies have therefore been included in the overall cost estimates to reflect this.

The estimates include separate allowances for:

- Property valuations.
- Property surveys.
- Property acquisitions.
- Property adjustments.

3.20.7 Public Utility Adjustments

Utilities costs include all adjustments, replacements, relocations and the like which are required as a consequence of the project, whether undertaken by the responsible authority, a contractor engaged by that authority, or undertaken by RTA either as part of the main contractor's works or by separate contract.

Existing major utilities have been approximately located using information provided by the relevant agencies. The length of likely service diversion and/or protection works required for the various route options has been estimated using the footprint of the option and these lengths have been used as the basis for utilities cost estimates. Allowance has been made for the following:

- Telstra fibre optic cables and coaxial cables, generally following the existing highway. Other Telstra copper cabling of varying sizes can be found throughout the study area, servicing residences and commercial facilities.
- Visionstream fibre optic cables from Bangalow to Ewingsdale, following the Tinderbox Creek valley.
- Optus fibre optic cables from Bangalow to Ewingsdale, following Tinderbox valley and also east along St Helena Road.
- Rous Water has 600 mm diameter trunk water supply mains from Emigrant Creek Dam to a treatment plant and reservoir at Knockrow, from Rocky Creek Dam to the same reservoir at Knockrow , and also east from Bangalow along the Byron Creek valley. There are also smaller distribution watermains owned by Rous Water and the Councils which may be affected as follows:
    - There is a 375 mm diameter watermain which follows the existing highway south of Knockrow. Ballina Shire Council also has an existing water supply main beside the existing highway south of Knockrow.
    - There is an existing 100 mm diameter distribution main on the east side of the existing highway between Knockrow and Broken Head Road.
    - There is an existing 100 mm diameter distribution main along Broken Head Road.
- Country Energy has power supply infrastructure in the area including a 66 kV power line which would be affected by Section D1.

In addition, the Casino-Murwillumbah railway passes through the study area. While the railway is no longer operating it is a requirement that provision should be made for the future re-opening of the railway. Allowance has therefore been made for a bridge above the railway line where it is crossed by any of the route options and sufficient vertical clearance has been provided.

A general allowance has also been made for other minor utility adjustments.

All allowances to date have been based on likely costs for similar types of work. The agencies themselves have not yet provided cost estimates.

3.20.8 Construction Costs

Infrastructure construction includes the construction of base infrastructure, environmental works, general activities and property adjustment associated with construction works. Allowance is also included for construction audits, site management and surveillance.

The comparative cost estimates have been based on detailed quantities derived from the 3D model of the route option sections. All access roads have also been modelled in 3D to confirm the feasibility and extent of local access road requirements.

The methodology adopted has been to apply unit rates to the derived quantities. The unit rates are based on historical data, with care taken to ensure that the adopted rates reflect similar work items and are corrected as required for inflation and site conditions. Rates are inclusive of contractor's overheads and profit.

3.20.9 Handover Costs

Handover costs are likely to be incurred by RTA because construction of the upgraded highway on a new alignment is likely to result in the handover of the existing highway to the two councils. No detailed discussions have been held with either council on this matter.

3.21 Risk and Contingency Allowances

Allowances for risk and contingency have been included in accordance with the principles described in the RTA Project Estimating Manual and with consideration of the issues raised in the project risk management procedures.

3.22 Comparative Cost Estimates for the Short List of Route Options

Based on the footprints of the shortlisted options and the methodology previously described, the comparative cost estimates are in the range $373 million to $497 million. These figures are based on 2006 construction costs and include all costs as previously noted that are associated with the design, construction and handover of the project.

The comparative cost estimates for each option are shown in **Table 3.16** and further details are provided in **Appendix C** (note: the numbering of route options used is described in **Chapter 6**).

3.22.1 Comparison of Cost to Those in the RODR

The costs shown in **Table 3.16** indicate greater variations in costs between options than were identified in the RODR. These greater differences are a result of: the design development process; adopting 2006 construction costs; better definition of construction requirements; and higher land acquisition costs. The cost of Options C and D has increased significantly relative to Options A and B for the following reasons:

- Estimated costs for land acquisition are relatively higher than expected.
- Cost of additional structures required because of geotechnical instability on the escarpment.
- Additional costs associated with soft soil and earthworks, due to additional geotechnical and hydrology investigations and availability of more detailed survey.
- Significantly higher costs for drainage structures necessary to meet flood passage requirements arising from the flood modelling.

Tunnel option T2 remains more expensive than T1 due to the need to reconstruct a greater length of the existing highway and also because the T2 tunnel would be slightly longer.

Table 3.16 Comparative Cost Estimates for Short Listed Route Options ($ millions)

Option Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Comprising segments	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B
	A1a	B1a	A1a	B1a	B1a	A1a	A1a	B1a	A1a
	A1b	A1b	B1b	B1b	A1b	A1b	B1b	B1b	A1b
	A1c	A1c	A1c	A1c	B1c	B1c	B1c	B1c	A1c
	A2	A2	A2	A2	A2	A2	A2	A2	B2
	T1	T1	T1	T1	T1	T1	T1	T1	T1
Cost	$383	$388	$384	$389	$378	$373	$373	$378	$426

Option Number	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Comprising segments	A/B	A/B	A/B	A/B	A/B	A/B	A/B	C/D	C/D
	B1a	A1a	B1a	B1a	A1a	A1a	B1a	C1	D1
	A1b	B1b	B1b	A1b	A1b	B1b	B1b	T1	T1
	A1c	A1c	A1c	B1c	B1c	B1c	B1c		
	B2	B2	B2	B2	B2	B2	B2		
	T1	T1	T1	T1	T1	T1	T1		
Cost	$431	$427	$431	$420	$415	$416	$421	$486	$456

Option Number	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
Comprising segments	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B
	A1a	B1a	A1a	B1a	B1a	A1a	A1a	B1a	A1a
	A1b	A1b	B1b	B1b	A1b	A1b	B1b	B1b	A1b
	A1c	A1c	A1c	A1c	B1c	B1c	B1c	B1c	A1c
	A2	A2	A2	A2	A2	A2	A2	A2	B2
	T2	T2	T2	T2	T2	T2	T2	T2	T2
Cost	$395	$400	$396	$401	$389	$385	$385	$390	$438

Option Number	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
Comprising segments	A/B	A/B	A/B	A/B	A/B	A/B	A/B	C/D	C/D
	B1a	A1a	B1a	B1a	A1a	A1a	B1a	C1	D1
	A1b	B1b	B1b	A1b	A1b	B1b	B1b	T2	T2
	A1c	A1c	A1c	B1c	B1c	B1c	B1c		
	B2	B2	B2	B2	B2	B2	B2		
	T2	T2	T2	T2	T2	T2	T2		
Cost	$443	$438	$444	$432	$427	$428	$432	$497	$468

4 Route Options Display Consultation

As noted in **Section 1.7**, the community and agency submissions received on the RODR are one of the three streams of input to the preferred route selection process described in **Chapter 7**. Details of the public display and the analysis of issues raised in submissions are documented in the *Tintenbar to Ewingsdale Route Options Submissions Report* (RTA 2006). This chapter provides a summary of the public display of the shortlisted route options and the issues rose in the submissions.

4.1 Route Options Display Activities

The display of route options commenced on 21 October 2005 and concluded on 2 December 2005. A range of consultation tools were used to facilitate and encourage community and stakeholder feedback on the route options, including advertisements, information brochures, landowner meetings, route options displays, a community information centre, and static displays.

4.1.1 Advertisement and Information Brochure

Advertisements were placed in local and regional newspapers, and notice of the display was provided to members of the community within the study area and other relevant stakeholders. A Route Options Display brochure described the key issues associated with the options. The brochure provided details of display locations and times, and availability of additional information (project information line, RTA website and RTA Project Manager).

4.1.2 Community Information Centre and Static Displays

Route options were displayed at a Community Information Centre located at the Bangalow Showgrounds during the display period, and members of the Project Team were in attendance. Staffed displays were also held at various locations during the display period as listed in **Table 4.1**. Static displays were also provided at specified locations in Newrybar, Ballina, Mullumbimby, Grafton, and Lismore.

Table 4.1 Staffed Displays and Community Information Centre Timetable

Location	Date
Staffed Display	
Bangalow A & I Hall	29 October 2005
Broken Head Hall	4 November 2005
Lennox CWA Hall	5 November 2005
Newrybar Hall	9 November 2005
Ewingsdale Hall	12 November 2005
Community Information Centre	
Bangalow Showgrounds	Wednesdays 10am-4pm
26 October to 11 November 2005	Thursdays 10am-6pm
	Fridays 10am-4pm

Key objectives of community and stakeholder involvement included:

- Ensure an open accountable and transparent community involvement process.
- Ensure all potentially affected property owners and interested stakeholders were provided with sufficient information about the project and the likely impacts so that they could provide informed input to the route selection process.

- Ensure appropriate and direct communication with property owners and/or managers in relation to access and investigations on landholdings within the study area by Project Team members and/or RTA representatives.
- Encourage community support and involvement in the project to facilitate better and more generally accepted outcomes.
- Provide a range of accessible opportunities for stakeholders, interested groups and the wider public to contribute to the project through issues identification, information provision and options evaluation.
- Build an ongoing relationship between the RTA, its contractors, and stakeholders in order to gain long term support for the project, and in particular the preferred route.

4.1.3 Landowner Meetings

The Project Team held over 100 meetings with land owners and/ or occupiers potentially directly affected by the shortlisted route options. This provided a direct mechanism whereby the concerns of potentially affected land owners/occupiers could be expressed and any issues discussed.

4.1.4 Website

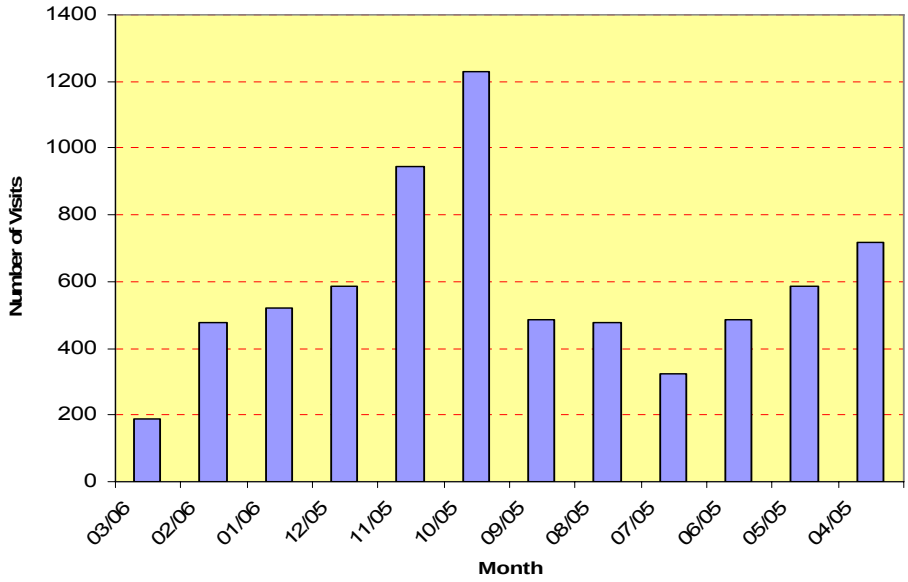
A website was established in the early stages of the project. The objective of the website is to provide easy access to community updates, public information and details of community involvement such as CLG and AFG meeting notes. Technical information including project reports, program objectives, details of the development process and field investigations are also displayed on the website and have been a useful source of information for many community members.

Figure 4.1 identifies the number of times the website has been visited between April 2005 and March 2006. Within this timeframe, peak visitation periods were experienced in October and November 2005 when the route options display was held. During the display period, the RODR was the most frequently downloaded document.

The website is also used as a communication tool whereby community members can communicate with the Project Team via email. During the route option display period, community members were also able to supply feedback via the website.

Website activity peaked in October 2005 on announcement of the shortlisted route options.

Figure 4.1 Website Visits by the Public



4.2 Overview of Issues Raised in Submissions

The feedback received on the RODR was extensive and indicative of the many varied views within the community. A total of 19,192 submissions were received in the six weeks following the release of the RODR and during the route options display. Submissions have been sorted by type and issues raised, with all submissions entered into a database and fully considered. Weighting has not been given to those issues that received the most responses; rather the submissions have been used qualitatively to gather as much information as possible to use in the selection of the preferred route. **Table 4.2** provides a breakdown of the origins of the submissions received.

Form Submissions and Petition

There were two form submissions and one petition received. The first form submission was from the United Voices group and had four points, listed below:

- Move the interstate freight back to the New England Highway.
- Government to start investigation of alternative inland freight routes and rail options.
- Upgrade the highway to Class A within the existing corridor.
- Immediate start to a Class A Ballina Bypass.

The second form submission had five main points, listed below:

- Upgrade should occur within the existing corridor.
- No consultation with residences to the east of the highway before the study area was expanded.
- Highway upgrade on the coastal flats will increase environmental damage particularly the Newrybar valley and Coopers Shoot escarpment.
- Elimination of important agricultural land in the expanded study area.
- The highway upgrade was zoned and planned along the current alignment.

The petition requested the NSW Legislative Assembly to only consider route options that closely follow the existing Pacific Highway.

Feedback Forms

Feedback forms were analysed in respect of locality of the sender, route preferences, and the issues identified as most important. **Figure 4.2** shows that feedback forms received were largely from people who live in or near the study area.

Option preference as noted on the feedback forms is shown in **Figure 4.3**. (Not all feedback forms returned had a clearly stated preference between the options, thus the sum of those who favoured one option over another does not equal the total number of feedback forms received.)

Significance of community issues as noted on the feedback forms is shown in **Figure 4.4**.

Table 4.2 Origins of Submissions

	United Voices		Feedback Forms and Other Submissions	
Total received	**18,012**		**1,180**	
Address not counted*	1,776		358	
Total counted	**16,236**		**822**	
	Total	%	Total	%
Postcode 2478 (Ballina/Lennox)	4,922	30	114	14.0
Postcode 2479 (Bangalow/Coopers Shoot/Knockrow/Newrybar)	1,176	7	430	53
Postcode 2481 (Byron Bay/Broken Head)	3,731	23	121	15
Other NSW	4,733	29	121	15
Australia not NSW	1,255	7.5	36	4
Overseas	419	2.5	0	0

*Note: Origin of submission was not counted if an address was not provided, submission acknowledgement letter produced a 'Returned to Sender', duplicates, email only provided, illegible address and feedback forms being blank. The issues raised in these submissions were still incorporated into the report.

Figure 4.2 Feedback Forms by Area

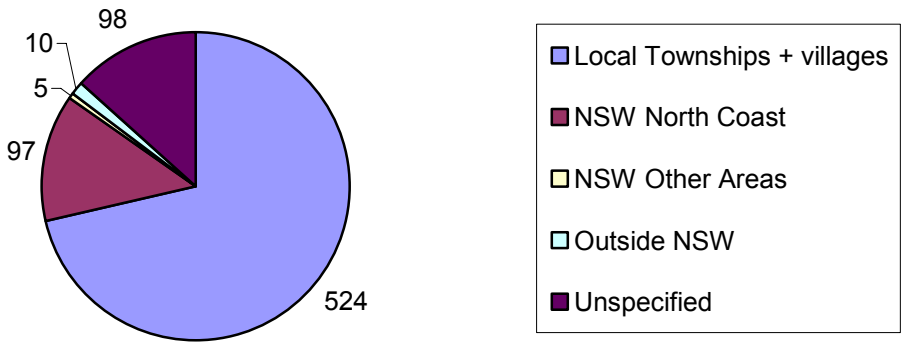


Figure 4.3 Option Preferences as Identified on Feedback Forms

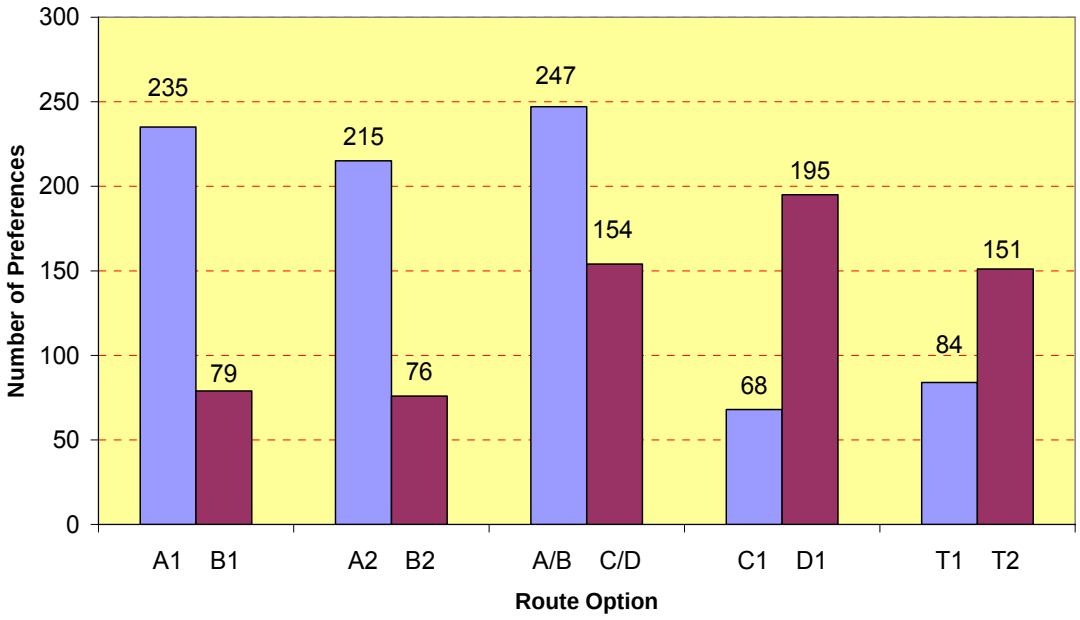
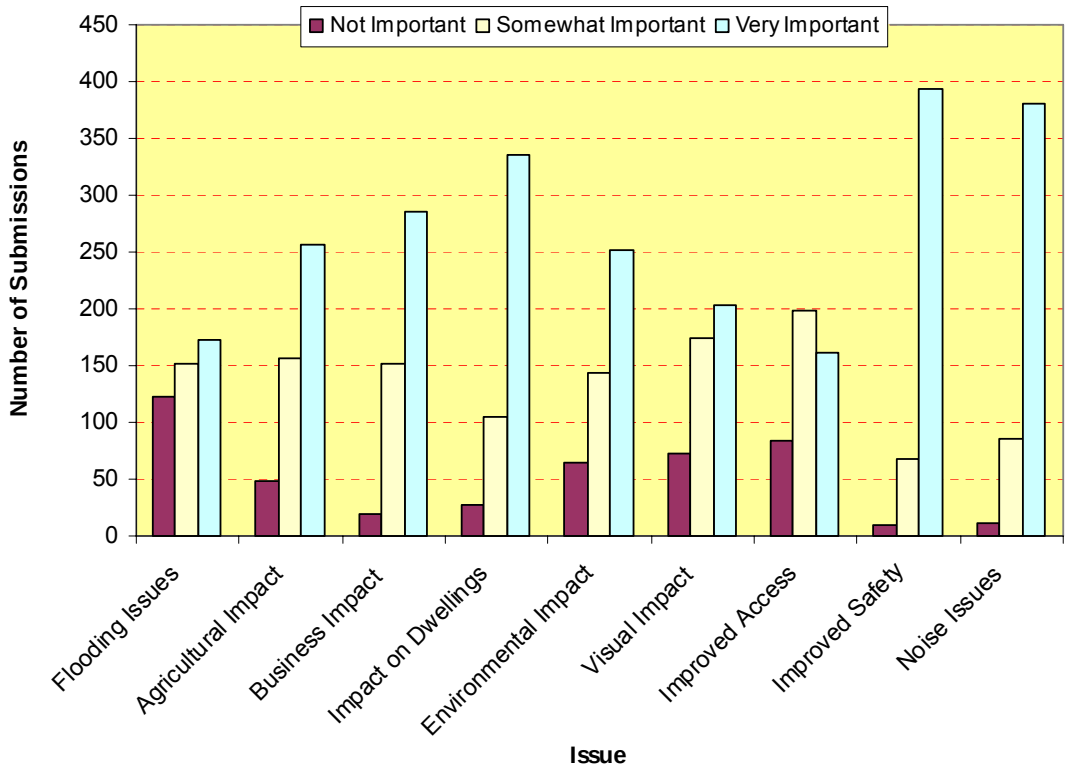


Figure 4.4 Significance of Issues as Identified on Feedback Forms



4.2.1 Community Submissions

A summary of the main issues raised in the submissions is provided in **Table 4.3**.

Table 4.3 Community Submissions Summary

Issue Title	Main Issues	Number of times issue raised	% of issues within the category
Community Consultation	Criticism of the consultation programme (including expansion of study area)	122	38.9%
	Concern as to how submissions (including "United Voices" submission) are treated	35	11.1%
	Influence of lobby groups	32	10.2%
	Uncertainty and anxiety caused by route selection process	28	8.9%
	Community being divided by process	20	6.4%
	Community representation on the CLG	18	5.7%
	Total	**255**	
Process	The RODR contained inaccurate or misleading information and impacts should just be considered for the road footprint not a 250 m wide corridor	36	22.0%
	Concern regarding the expansion of the study area	32	19.5%
	The selection process was flawed (for example a 'do-nothing' option was not considered)	22	13.4%
	The RODR lacked quality, detailed information	19	11.6%
	Concern regarding the criteria weighting	29	17.7%
	Total	**138**	
Strategic Planning	An inland route particularly for freight is a better option	525 + (United Voices 18,012)	57.3%
	Poor planning at the State and Federal level	93	10.2%
	Alternative routes (and modes) should be considered	71 + (United Voices 18,012)	7.8%
	The highway upgrade should not be fast tracked under public pressure	67	7.3%
	Total	**756**	
Engineering Design	Various route preferences offered based on engineering design and feasibility	334	46.2%
	Concern over design guidelines including confusion regarding Class A versus Class M, number of lanes required and speed limits	159	22%
	Upgrade on or near existing highway	242 +(United Voices 18,012)	33.5%
	Disturbance and use of existing highway during construction	25	3.5%
	Total	**760**	

Issue Title	Main Issues	Number of times issue raised	% of issues within the category
Tunnel	Support for a tunnel option	23	17.2%
	Opposition to a tunnel option	46	34.3%
	T1 versus T2 preferences	51	38.1%
	Total	**120**	
Access	Local road network impacts	19	17.3%
	Use of existing highway for local access and tourist drive	29	26.4%
	Interchanges	27	24.5%
	Access to individual properties	35	31.8%
	Total	**110**	
Safety	Road safety should be a priority	91	29.3%
	Existing safety concerns (for example black-spots) should be eliminated urgently to reduce accident	64	20.6%
	The existing highway is unsafe and demonstrates that heavy vehicles and cars don't mix	70	22.5%
	Fog is not a significant issue	69	22.2%
	Total	**294**	
Geology, Geotechnics and Soils	Difficulty of constructing in areas of instability	38	51.4%
	Difficulty of constructing in soft soils	21	28.4%
	Total	**59**	
Hydrology, Flooding and Water Quality	Impact on waterways generally and specific (including Knockrow, Emigrants, Platypus, Skinner and Byron Creeks) in terms of drinking water quality and aquatic ecology	267	63.1%
	Identification of flood prone land	65	15.4%
	Impacts on drainage hydrology	35	8.3%
	Impacts to springs and groundwater	32	7.6%
	Total	**399**	
Air Quality	General impacts on the community	47	39.8%
	Health impacts	14	11.9%
	Vehicle emissions and greenhouse gases	14	11.9%
	Total	**75**	
Ecology	Impacts to the coastal plain and escarpment	156	44.3%
	Data supplied by individuals not represented in the RODR	36	10.2%
	General extent of ecological impacts	33	9.4%
	Impacts to rehabilitation and revegetation projects	24	6.8%
	Impacts on the plateau	22	6.3%
	Total	**271**	

Issue Title	Main Issues	Number of times issue raised	% of issues within the category
Planning and Landuse	Route preferences provided based on agricultural impacts	287	35.2%
	Options along the existing would make best use of earlier decisions regarding the Ballina by-pass and the Bangalow by-pass as well as existing 9(a) zoning	228	28.0%
	Prime agricultural land should be avoided	150	18.4%
	Inconsistency with other environmental planning instruments	41	5.0%
	Consideration of future residential developments	29	3.6%
	Total	**735**	
Social and Business	Options preference based on concern regarding impact on communities and livelihoods	310	37.9%
	Options preference based on concern regarding impact on (acquisition of) residences	225	27.5%
	Impacts on tourism	43	5.3%
	Non-agricultural impacts to the local economy should be considered	40	4.9%
	Social and educational impacts on Newrybar School	32	3.9%
	Total	**650**	
Heritage	Impact on Non-Aboriginal heritage	25	58.1%
	Impact on Aboriginal heritage	10	23.3%
	Total	**35**	
Visual Impact and Urban Design	General visual amenity and route options preferences	127	47.4%
	Impacts to the scenic escarpment and coastal plain	96	35.8%
	Total	**223**	
Noise and Vibration	Route preferences based on impacts of upgrade on or near the existing highway	178	44.8%
	Route preferences based on impacts of upgrade away from existing highway	113	28.5%
	Total	**291**	
Land Acquisition and Compensation	The RTA has inadequate compensation arrangements for directly affected landowners as well as those landowners that would remain adjacent to the upgrade	131	52.8%
	Greater consideration should be given to the varying value of land throughout the study area	51	20.6%
	Land values will depreciate for lots away from the existing highway if coastal plains options chosen	33	13.3%
	Total	**215**	
Traffic and Transport	Concern that road improvements have proven to increase traffic volumes (particularly of heavy vehicles) dramatically	19	40.4%
	Total	**19**	

4.2.2 Agency Submissions

Key issues raised by agencies are listed in **Table 4.4**. Details of the submissions are included in the *Route Options Submissions Report*.

Table 4.4 Agency Submissions

Agency	Key Issues
Ballina Shire Council	Council advises a preference for the planning, design and construction of the approved Ballina Bypass route. Council identifies that use of the approved Ballina Bypass route alignment would avoid conflict with its current investigations concerning urban structure planning at Cumbalum Ridge.
Byron Shire Council	Council raises issues relating to maintenance of connectivity of communities and accessibility into town centres, while securing road safety, and highlights concerns regarding the location of interchanges and the potential impact to the local road network, in particular, the coast road from Lennox Head to Byron Bay. Council also raises a number of issues relating to ecological investigations undertaken and potential impacts.
NSW Department of Environment and Conservation	The DEC raises concerns relating to biodiversity conservation and ecological impacts, Aboriginal cultural heritage, air quality, noise impacts and water management.
NSW Department of Planning	The DoP highlights the importance of farming land in the area, and the significant impacts of fragmentation and consumption of farming properties.
NSW Department of Primary Industries	The DPI highlights the importance of farming land and agricultural activity in the area, and notes that all four of the shortlisted options would impact on important agricultural land to some degree.
Rous Water	Rous Water identifies particular concern with Options A1, B1 and C1 due to the close proximity to Emigrant Creek Dam, crossings of Emigrant Creek, and/or disturbance to the Emigrant Creek catchment. Rous Water also suggests a number of water quality management practices that should be carried out as part of the upgrade.
Jali Local Aboriginal Land Council	The Jali Local Aboriginal Land Council identifies concerns with respect to impacts to dwellings, and highlights the need to preserve the potential for tourism in the area. The Jali Land Aboriginal Land Council also identifies that the shortlisted route option traverse land of known past indigenous occupation and that there may be artefacts or items of indigenous heritage in the area.
Northern Rivers Regional Development Board	The Northern Rivers Regional Development Board identifies issues relating to transport planning, including consideration of impacts to the local road network, the separation of local and interstate traffic, safety on the highway, and mitigation measures to ensure residential amenity is protected from heavy vehicle traffic. The Northern Rivers Regional Development Board also highlights the importance of minimising impacts to agricultural land, and of impacts to the natural and cultural landscape.

4.3 Outcomes of Public Display of Route Options

As a result of feedback from the community and agencies, further engineering and environmental investigations were undertaken as described in **Chapter 3**. Additionally, relevant data obtained through the submissions was incorporated into the updated constraints analysis.

The outcomes of this stream of work are considered in the route selection process described in **Chapter 7**.

5 Value Management Analysis of Route Options

As noted in **Section 1.7**, the VMW is one of the three streams of input to the preferred route selection process described in **Chapter 7**. The value management process was established to review highway planning investigations and identify the values that are collectively important within the study area. As part of this process a Corridor Assessment Workshop was held in August 2005, to bring together a wide range of stakeholder interests and expertise, followed by the VMW in December 2005.

The assessments and evaluations of the VMW are described in detail in the *Tintenbar to Ewingsdale Value Management Workshop Report* (RTA 2006). The key issues and outcomes from the value management process are summarised below.

5.1 Corridor Assessment Workshop

The objective of the Corridor Assessment Workshop was to obtain a common understanding of the highway upgrade project and the work undertaken to date, and to agree on assessment criteria and weightings with which to evaluate corridor options later in the project's development.

The Corridor Assessment Workshop drew from the perspectives and detailed specialist knowledge of the workshop participants. The participants identified challenges that the project must address and what the project must achieve to be successful.

Assessment criteria were developed for three key perspectives – Functional; Social and Economic; and Natural and Cultural Environment. The group developed weightings for the criteria within each of the three perspectives.

5.2 Value Management Workshop

The objective of the VMW was to bring together key stakeholders to:

- Recap the findings of the Corridor Assessment Workshop undertaken in August 2005.
- Share with participants what has happened since the Corridor Assessment Workshop.
- Review the shortlisted options developed and identify potential improvements to meet the project objectives.
- Evaluate the shortlisted options using the assessment methodology developed in the Corridor Assessment Workshop.
- Recommend a direction to progress the project.

Stakeholders participating in the VMW included: Ballina and Byron Shire Councils, DoP, Department of Natural Resources (DoNR), DEC, DPI, Rous Water, Northern Rivers Regional Development Board, Jali Local Aboriginal Council, Arakwal Group, Department of School Education, Newrybar Public School, NSW Ambulance, Rural Fire Service, Optus, NRMA, NSW Road Transport Association, Rail Infrastructure Corporation, and representatives of the CLG and AFG established for the project.

The VMW group reviewed the material presented at the Corridor Assessment Workshop including the project program, objectives, and framework, and a preliminary analysis of issues raised in the RODR submissions.

Participants embraced the methodology developed in the Corridor Assessment Workshop, but the assessment criteria and weightings were revisited and a modified set of criteria were agreed for use at the VMW. The assessment criteria were recast under four key perspectives – Functional, Social, Economic, and Natural and Cultural Environment – and re-weighted. The key assessment criteria for each perspective were identified as:

- Functional Perspective
    - Improve safety and reduce accidents (local and on the highway) e.g. fog, staging to bring on results earlier, etc.
    - Potential for effective access points and links.
    - Buildability.
    - Use of existing highway, infrastructure and utilities.
- Natural and Cultural Environment Perspective
    - Impact on Aboriginal cultural heritage.
    - Impact on native and regenerated vegetation (including threatened species of flora and fauna).
    - Impact on EECs and remnant native vegetation.
    - Risk to drinking water catchments.
    - Impact on wildlife corridors and terrestrial and aquatic habitats.
- Social Perspective
    - Noise – social impact of noise: number, relative, new receivers.
    - Severance of communities.
    - Impact on the community's views (including quality of life and landscape).
    - Proximity to sensitive receivers (e.g. school, health, air quality).
    - (Social) Impact on agricultural lands.
- Economic Perspective
    - Impact on agricultural lands.
    - Impact on local businesses – directly and indirectly.
    - Impact of changed hydrology (flooding, springs etc).

The VMW group reviewed the shortlisted route options using their weighted assessment criteria with a view to differentiating the corridor options under each of the four key perspectives. The VMW ranking of the shortlisted route options is shown in **Table 5.1**. The options were ranked on a comparative basis, 1 was the highest ranking.

Table 5.1 Rankings Ascribed by the Value Management Workshop

	Functional	Natural & Cultural Environment	Social	Economic	Capital $(M)
Option A1 – A2	5	1	1	1	320
Option A1 – B2	5	2	2	4	340
Option B1 – A2	1	2	3	1	310
Option B1 – B2	1	4	5	4	330
Option C	1	5	5	6	320
Option D	1	5	3	1↓	305
Option T1	1	1	1	2	80
Option T2	1	1	2↑	1	90

Note: ↓ – A consensus was not reached regarding agricultural land values; further studies were requested. Due to the high weighting of the criterion, Option D could move from the highest ranked option to the lowest ranked option in the Economic perspective.
↑ – The VMW considered there to be little difference between T1 and T2 on social issues and that further noise analysis might demonstrate an increased favourability of T2 compared to T1.

5.3 Outcomes of Value Management

The VMW group also provided recommendations for further investigation and route option refinement. The conclusions and recommendations agreed by the VMW group are listed below.

- All corridor options have impacts in the study area (there is no perfect option).
- Option B2 and Option C1 should not be considered further.
- Option A1, Option A2, Option B1, and Option D were preferred over other options, subject to further investigations.
- Further investigations recommended included:
    - The agricultural economic impacts of Option D (including agricultural land values and relative impacts).
    - The noise impacts of tunnel approach options T1 and T2.
    - Examination of frequent rainfall events that relate to farming irrigation practices and water management in the zone between the surface and 'ground water' levels.
    - Air quality and emissions from potential highway corridors; and establish a view on the potential impact on public health.
- There is opportunity to look at combinations of A1 and B1 to find the most suitable alignment in terms of the assessment values recorded.
- Further investigation of economic impacts for both the regional and local perspective.

The results of the VMW were reported to the community via a notice placed in local newspapers in late December 2005. The VMW Report was placed on the RTA project website in March 2006. The outcomes of this stream of work are considered in the route selection process described in **Chapter 7**.

6 Technical Assessment of Short List of Options

As noted in **Chapter 2**, the process for selecting the preferred route included the development of initial options, the long list of options and the short list of options as described in the RODR. The RODR provided the outcome of the application of the Sieve 1 criteria documenting the selection of the short list of options, and the summary of impacts of the short list of options such that the local communities, agencies and other stakeholders could review the proposed short list and provide submissions and feedback to the Project Team. The next step in the iterative planning process is the technical analysis of the short list of options which is provided in this chapter. This technical assessment is based on the short list of options (as modified since the RODR) and their performance based on the Sieve 2 criteria. This step of the process includes the following:

- Review of the short list of route options, including the subsections.
- Review and update of evaluation criteria used for the technical analysis.
- A pairwise process undertaken for weighting of the Sieve 2 evaluation criteria and sensitivity analysis.
- Evaluation of performance of the short list of route options against the Sieve 2 evaluation criteria.
- Reduction of the short list to the top performing options.
- Comparison of the top performing options.
- Identification of the best performing route option as the outcome of the technical analysis.

It should be noted that project costs are not considered in the technical assessment. Costs are considered in the selection of the preferred route as described in **Chapter 7**.

6.1 Review of the Short List of Route Options

6.1.1 Options and Sections

The shortlisted route options are shown in **Figure 2.3** and comprise Options A, B, C, D, and the Tunnel Section. The sections that make up the various options are Section A/B, A1, A2, B1, B2, C/D, C1, and D1. The Tunnel Section includes two approach options T1 and T2. As there is very little difference in the corridor plans of the tunnel options, rendered perspectives are shown in **Figure 6.1** and **Figure 6.2** to highlight the differences in the options.

As shown in **Figure 2.3**, Options A and B cross at several locations and this provides the opportunity for assessment of additional options by utilising a combination of A and B sections. For example A/B, A1, A2, T1 is one option and A/B, A1, B2, T1 is an alternative option. Additionally, all option combinations can connect with either tunnel approach T1 or T2. This results in a total of 12 possible option combinations, six with T1 and six with T2.

6.1.2 Segmentation of Sections A1 and B1

In addition to the combination of sections described above, Sections A1 and B1 cross at two locations as shown in **Figure 6.3**. As noted in **Section 3.18**, A1 and B1 were divided into subsections to allow all feasible combinations of the short list of route options to be assessed. Including the subsections, there are 14 different segments under consideration: A/B, A1-a, B1-a, A1-b, B1-b, A1-c, B1-c, A2, B2, C/D, C1, D1, and T1 and T2.

The various combinations of these segments were assessed separately and result in a total of 36 option combinations between Sandy Flat Road and the Ewingsdale interchange, 18 with T1 and 18 with T2. For reporting purposes, the various combinations are numbered Option 1 to 36 with Options 1 to 18 linking with T1, and Options 19 to 36 linking to T2. The route option combinations with T1 and T2 are listed in **Table 6.1** and **Table 6.2** respectively.

Figure 6.1 Option T1 Rendered Perspective

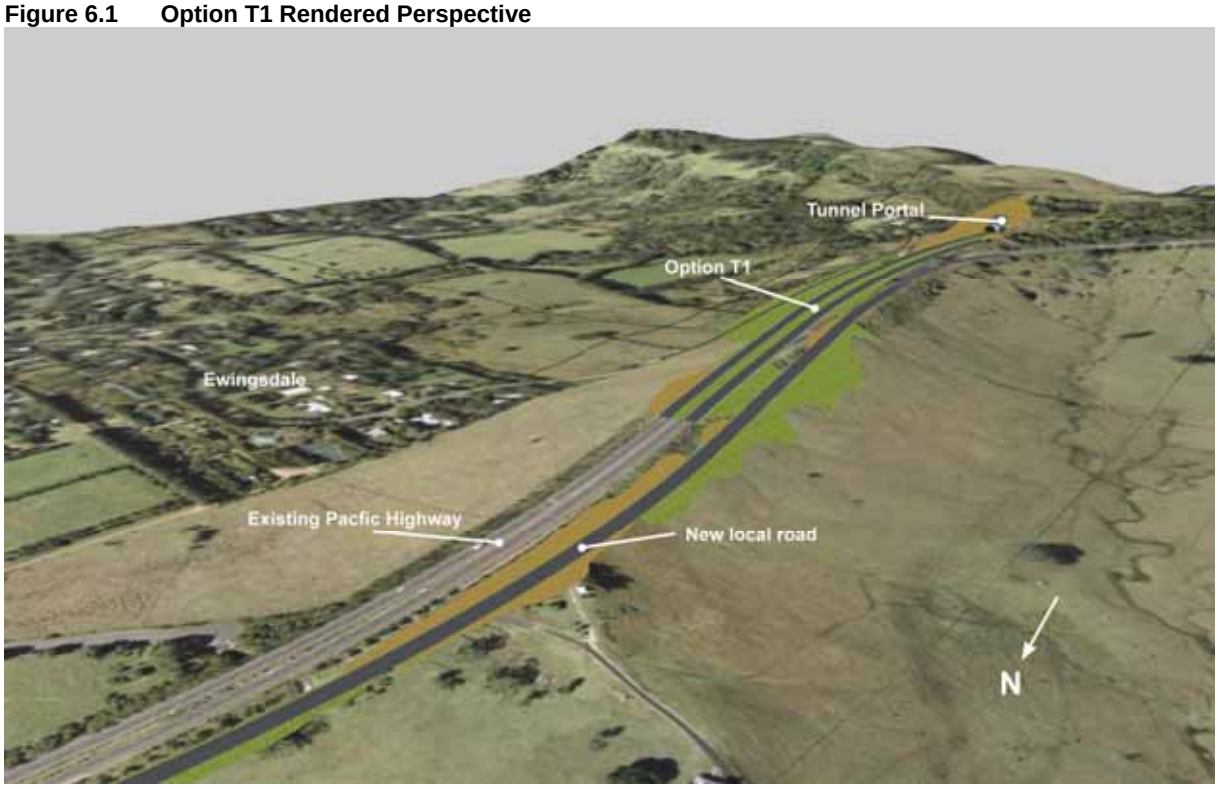


Figure 6.2 Option T2 Rendered Perspective

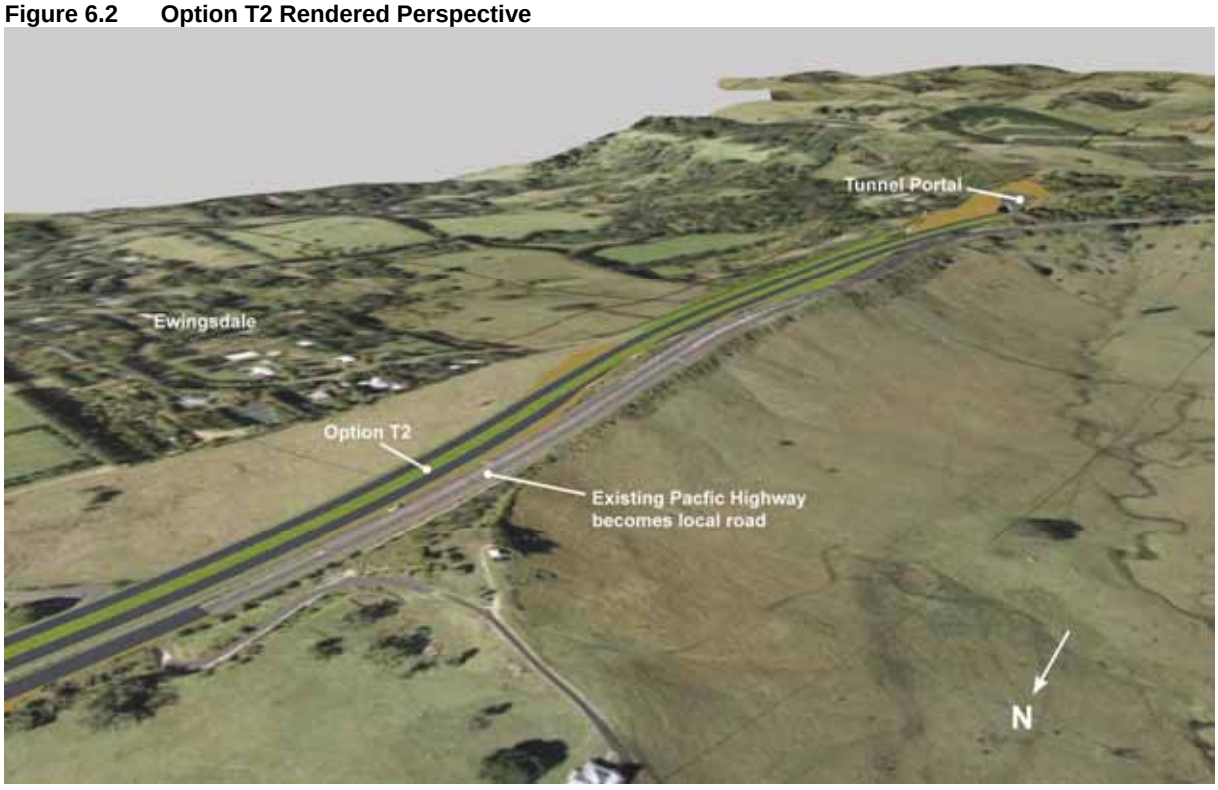


Figure 6.3 Subsections for Sections A1 and B1

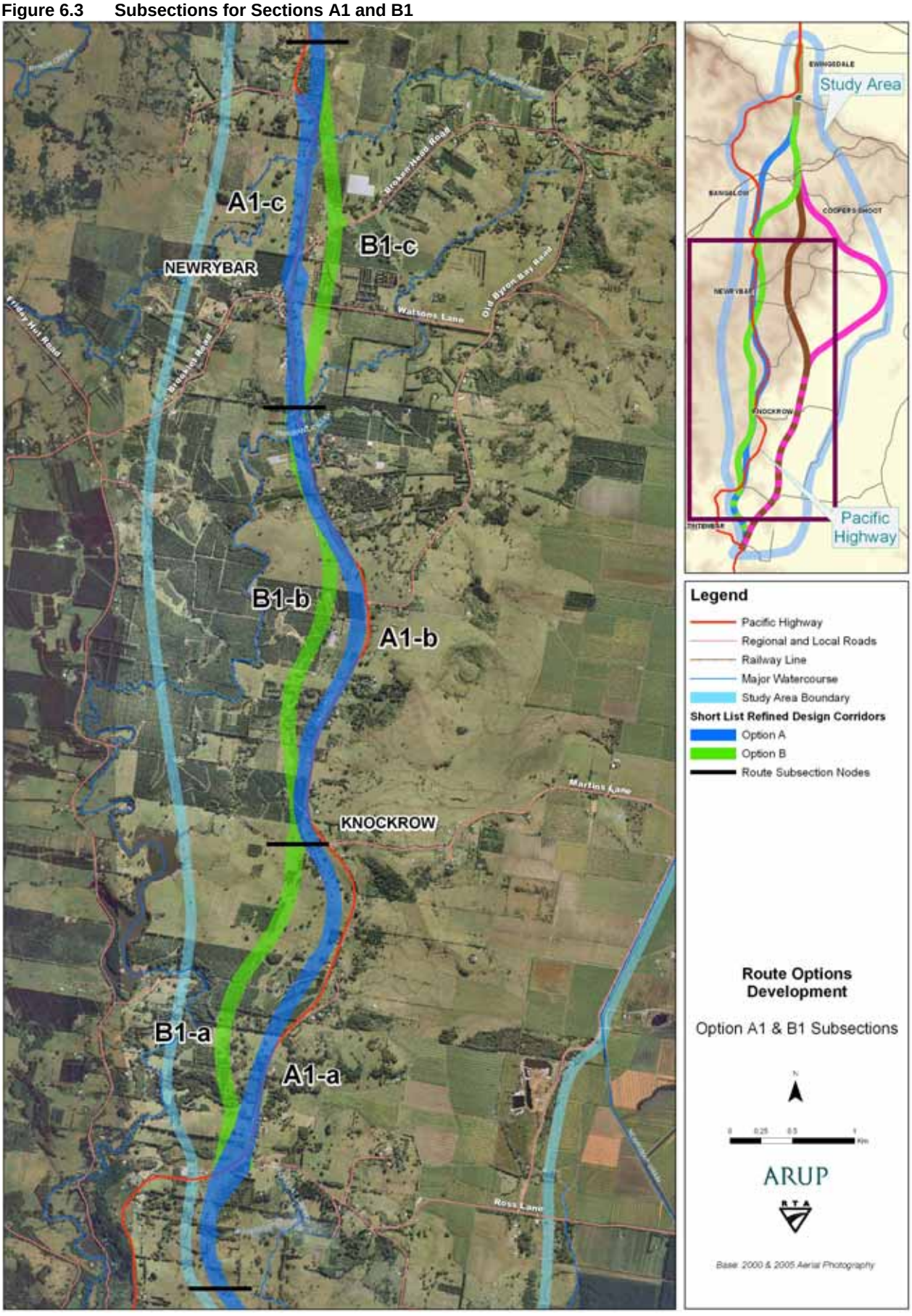


Table 6.1 Route Options with T1

Option No.	1	2	3	4	5	6	7	8	9
Comprising Segments	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B
	A1a	B1a	A1a	B1a	B1a	A1a	A1a	B1a	A1a
	A1b	A1b	B1b	B1b	A1b	A1b	B1b	B1b	A1b
	A1c	A1c	A1c	A1c	B1c	B1c	B1c	B1c	A1c
	A2	A2	A2	A2	A2	A2	A2	A2	B2
	T1	T1	T1	T1	T1	T1	T1	T1	T1

Option No.	10	11	12	13	14	15	16	17	18
Comprising Segments	A/B	A/B	A/B	A/B	A/B	A/B	A/B	C/D	C/D
	B1a	A1a	B1a	B1a	A1a	A1a	B1a	C1	D1
	A1b	B1b	B1b	A1b	A1b	B1b	B1b	T1	T1
	A1c	A1c	A1c	B1c	B1c	B1c	B1c		
	B2	B2	B2	B2	B2	B2	B2		
	T1	T1	T1	T1	T1	T1	T1		

Table 6.2 Route Options with T2

Option No.	19	20	21	22	23	24	25	26	27
Comprising Segments	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B
	A1a	B1a	A1a	B1a	B1a	A1a	A1a	B1a	A1a
	A1b	A1b	B1b	B1b	A1b	A1b	B1b	B1b	A1b
	A1c	A1c	A1c	A1c	B1c	B1c	B1c	B1c	A1c
	A2	A2	A2	A2	A2	A2	A2	A2	B2
	T2	T2	T2	T2	T2	T2	T2	T2	T2

Option No.	28	29	28	29	30	31	32	35	36
Comprising Segments	A/B	A/B	A/B	A/B	A/B	A/B	A/B	C/D	C/D
	B1a	A1a	B1a	B1a	A1a	A1a	B1a	C1	D1
	A1b	B1b	B1b	A1b	A1b	B1b	B1b	T2	T2
	A1c	A1c	A1c	B1c	B1c	B1c	B1c		
	B2	B2	B2	B2	B2	B2	B2		
	T2	T2	T2	T2	T2	T2	T2		

6.2 Sieve 2 Methodology

The Sieve 2 methodology comprises a technical evaluation of the short list of route options as a guide to selection of the preferred route. The analysis is based on:

- Further engineering, environmental and economic investigations, including investigations addressing issues raised in community and agency submissions following public display of the shortlisted options and the value management assessment of the shortlisted route options.
- Refined shortlisted route options as described in **Sections 3.17, 3.18** and **3.19**.

The framework for the Sieve 2 assessment of the shortlisted route options includes the following key steps:

- Selection of the Sieve 2 evaluation criteria.
- A pairwise comparison of evaluation criteria conducted by the Project Team to determine the weightings to be applied to the evaluation criteria scores.
- Assessment of each route option combination against the evaluation criteria.
- Application of pairwise weightings to the raw (base evaluation criteria) scores of the 36 options.
- Sensitivity testing on the outcomes of the pairwise ratings.
- Comparison and evaluation to determine preferred route recommendation based on technical analysis.
- Further design refinement of the emerging preferred route.

Key steps in the methodology are discussed in the following sections.

6.3 Sieve 2 Evaluation Criteria

The assessment of the long list of route options, addressed in the RODR, included the development of a set of 39 criteria used in the Sieve 1 analysis. As described in the RODR, the Sieve 1 criteria were established prior to the development of route options with significant input from the CLG.

Sieve 1 criteria were reviewed following the route options display, and criteria that did not provide a differentiation between the shortlisted route options were examined closely and either dropped or amended to reflect the comparative differences in the shortlisted options. The Sieve 2 criteria developed to assess the short list of options are a refinement of Sieve 1 criteria and reflect input from community and agency submissions and the value management process.

The Sieve 2 evaluation criteria and performance measures are listed in **Appendix B**. Categories or 'silos' of criteria were established to assess impacts by similar groupings of issues as described in **Section 6.4**. The Sieve 2 criteria are grouped as follows:

- Safety and Functionality.
- Social and Economic.
- Natural and Cultural Environment.

Key Sieve 2 criteria and measurables added in response to community and agency concerns are listed in **Table 6.3.** Costs are not included in the Sieve 2 evaluation criteria. Costs are addressed in the selection of the preferred route as described in **Chapter 7**.

Table 6.3 New and Revised Criteria since RODR

New Criteria
• Travel efficiency
• Economic impact on agricultural business
• Impacts on Northern Rivers regional economy
• Impacts on local economy
• Air quality (greenhouse gases)
• Drinking water catchments
• Lifestyle
Revised Criteria
• Safety – the results of the safety audits conducted on the short list of route options were used
• Buildability – a non-financial review incorporating a variety of construction risks and a qualitative assessment of how construction can be staged
• Noise – addition of houses exceeding DEC's ECRTN target levels. Also, the grade cutoff for determining where higher peak noise levels (particularly from engine braking) would be likely to occur was lowered from 4.5% to 3% based on noise monitoring results
• Springs – consideration given to springs located in what would become deep double sided cuts, because mitigation measures would be more difficult in such cuttings

6.4 Pairwise Process

A pairwise process was used to weight the relative importance of the Sieve 2 evaluation criteria. The process used was similar to that adopted for the Sieve 1 analysis of the long list of route options, as described in the RODR, but with one important difference. The pairwise process in Sieve 1 compared all of the selection criteria against each other; in Sieve 2, the pairwise process was conducted separately for each of the silos.

The Sieve 2 pairwise weighting process does not attempt to determine the relative importance of each of the three silos, but reports separately on results of the assessments within each silo. This approach avoided value judgements across the diverse range of criteria and eliminated the ranking of potentially conflicting goals (i.e. terrestrial ecology impacts versus social and economic impacts). This approach also aligns the technical assessment of route options with the process adopted at the VMW; thus allowing a more transparent comparison of the two approaches to selection of the preferred route.

The process is spreadsheet based and provides a weighting or relative importance for each criteria. The advantage of using a pairwise approach is that it distinguishes between benefits and disbenefits potentially offered by an option rather than reacting to specific impacts or rating all impacts as high.

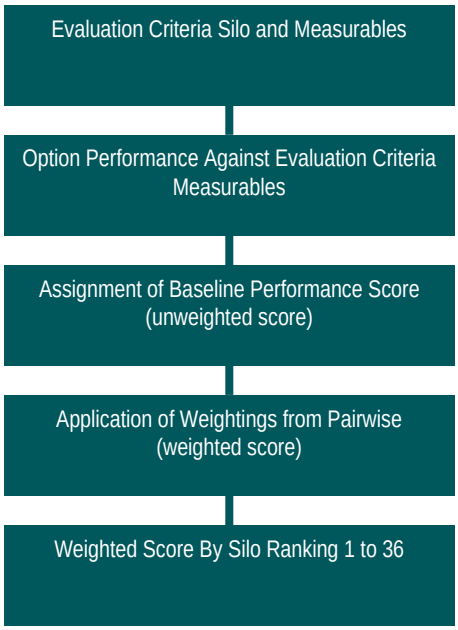
The Sieve 2 pairwise exercise was undertaken by the Project Team (RTA and Arup). Sensitivity testing was conducted on the pairwise results using a range of weightings including the Corridor Assessment Workshop and VMW weightings (see **Appendix D**). Application of the pairwise results in the route selection process is described in the following sections.

6.5 Performance of the Route Options Against Evaluation Criteria

Following completion of the design refinements described in **Section 3.4** and updating of constraints mapping to reflect the latest available data, each of the 14 different sections under consideration (A/B, A1-a and B1-a, A1-b and B1-b, A1-c and B1-c, A2 and B2, C/D, C1 and D1, and T1 and T2) were measured against each evaluation criteria. The process for determining the performance of the options against the Sieve 2 evaluation criteria involves a 'scoring' and ranking approach outlined in **Figure 6.4** and described in **Sections 6.5.1** and **6.5.2**. This approach was adopted because it:

- Allows a differentiation when comparing route option combinations, even though the differences may be quite small.
- Ensures a consistent approach in the Sieve 2 process for all of the evaluation criteria.
- Allows for a review of the base values to better understand differences between the route options for specific criteria and whether these are truly significant.

Figure 6.4 Process to Determine Performance of Options by Silo



6.5.1 Sections and Subsections Relative Impacts (Unweighted Results)

For each of the 36 route option combinations, the overall measure against each evaluation criteria was derived by adding the sections and subsections. For example, lengths located within the 1% AEP flood extent were summed for individual sections to get the total length within the 1% AEP flood extent for each of the different 36 route options. The results of the criteria measurements are shown in **Appendix E**.

The result of this step of the process was to establish baseline scores for each of the 36 route options against each evaluation criteria. The baseline scores were then adjusted to a relative score of 1 to 5, with the worst performing of the 36 route combinations scoring 1 out of 5 and the best performing of the 36 scoring 5 out of 5. A linear adjustment between 1 and 5 was made for the remaining route options. For example, the plateau options pass through about 1 km that would be within the 1% flood extent while Options 18 and 36 incorporating Section D1 pass through 8.1 km of land within the 1% AEP flood extent. The plateau options received a relative score of 5 out of 5 for this category while Options 18 and 36 incorporating Section D1 were allocated a relative score

of 1 out of 5. Options 17 and 35 incorporating Section C1 pass through 4.9 km of land within the 1% AEP flood extent and received a relative score of 3 out of 5 against this criteria.

6.5.2 Application of Weightings from Pairwise

The next step in the process was to apply weightings to the relative scores for each evaluation criteria within each silo by multiplying the relative scores by the percentage weighting derived from the pairwise analysis. For example, the relative scores of 5.0 out of 5 received by plateau options for 'length of route within the 1% AEP flood extent' are multiplied by the weighting of 7.3% for this criteria to give a weighted score of 0.36. Similarly, the relative score of 1.0 out of 5 received by Options 18 and 36 is multiplied by the weighting of 7.3% to give a weighted score of 0.07 and the relative score of 3.0 out of 5 received by Options 17 and 35 is multiplied by the weighting of 7.3% to give a weighted score of 0.22. Applying the weightings to the relative scores of each evaluation criteria and then summing within each silo gives the weighted total score of each route option within each silo.

The weighted total score of each route option within each silo was then compared to the weighted total scores of the other 35 route options and the options have been ranked for each silo from 1 (best performing route option in that silo) to 36 (worst performing route option in that silo).

The results of the weighting process are summarised in **Appendix F**.

6.6 Reduction of Options to Top Performers

6.6.1 Identification of Top Performers

As the process described in **Section 6.5** involves 36 options, it is necessary to narrow down the results to the top performing options prior to selecting the best performing option. Review of the results provided in **Appendix F** shows that there is no option which performs very well in all of the three silos. Options which perform very well in one silo tended to perform poorly in at least one other silo. For example Option A combined with T1 (Option 1) ranked 8th out of 36 for Natural and Cultural Environment, but ranked 36th out of 36 for Safety and Functionality and 34th out of 36 for Social and Economic.

Therefore identifying the top performing options is not simply a matter of identifying options which perform well in all three silos; there are no options that ranked within the top 10 in all silos.

The approach adopted to identify the top performing options was selection of options that fulfilled two principles:

- Provide a reasonably balanced performance across the three silos.
- Perform well overall when the performance in the three silos is assessed.

For each principle, the top 10 options were identified. This cut-off was used as it is unlikely that the preferred route would come from an option which does not perform in the top third using at least one of the two principles. Attention was then focussed on the better performing options for selection of the preferred route.

The two methods of identifying the top 10 options using each principle are as follows:

- Method 1 – This process identifies options which performed poorly in one or more silos and therefore would not provide balanced performance overall. By culling options which ranked in the bottom third in any one silo (i.e. did not rank in the top 25 out of 36), 26 options are eliminated and 10 of the 36 options remain in contention (see **Table 6.4**).
- Method 2 - Ranking the 36 options according to the arithmetic average of its ranking in each of the three silos. For example Option 1 ranked 36th in Safety and Functionality, 34th in Social and Economic and 8th in Natural and Cultural Environment. This corresponds to an average ranking of 26th, and when this average rank is compared to the average rank of the other 35

route options then the overall ranking of Option 1 is 33rd out of 36. Unlike Method 1, this method allows a route option combination to be rated well overall even if it performed poorly in one silo, as long as it performs well in the other silos. **Table 6.4** lists the 10 top performing options under Method 2.

- Application of the two methods results in the identification of seven options which meet both principles as shown in **Table 6.4**. Common sections contained in these top performers include: **A/B, A1-a, B1-a, A1-b, B1-b, B1-c, A2, B2, T1 and T2**.

Table 6.4 Top Performing Options*

Option	Combination of Sections						Method 1 Top 10	Method 2 Top 10
7	A/B	A1a	B1b	B1c	A2	T1	X	X
8	A/B	B1a	B1b	B1c	A2	T1	X	X
15	A/B	A1a	B1b	B1c	B2	T1	X	X
16	A/B	B1a	B1b	B1c	B2	T1		X
23	A/B	B1a	A1b	B1c	A2	T2	X	X
24	A/B	A1a	A1b	B1c	A2	T2	X	
25	A/B	A1a	B1b	B1c	A2	T2	X	X
26	A/B	B1a	B1b	B1c	A2	T2	X	X
31	A/B	B1a	A1b	B1c	B2	T2	X	
32	A/B	A1a	A1b	B1c	B2	T2	X	
33	A/B	A1a	B1b	B1c	B2	T2	X	X
34	A/B	B1a	B1b	B1c	B2	T2		X
35	C/D	C1	T2					X

* Shaded options are top performers in both methods

6.6.2 Elimination of Poor Performing Options and Sections

The process of identifying the seven top performing options allows elimination of a number of route sections as described below:

Subsection A1-c

Of the 36 option combinations, 16 incorporate Subsection A1-c which is interchangeable with Subsection B1-c. None of the options incorporating A1-c meet the desired principles measured in Methods 1 or 2.

Evidence for the elimination of Subsection A1-c is apparent by comparing option combinations that are identical apart from A1-c or B1-c. For example, Option 11 can be compared to Option 15. Based on the adopted evaluation criteria and weightings, Option 15 containing Subsection B1-c performs better than Option 11 containing Subsection A1-c in each of the three silos. Subsection B1-c therefore performs better than A1-c using both Method 1 and Method 2.

The difference is most pronounced in the Social and Economic silo. The primary reasons for the better performance of B1-c is that the residential, noise and lifestyle impacts of B1-c are considerably reduced compared to A1-c which passes close to Newrybar.

Subsection A1-c has therefore been eliminated on the basis of its poorer performance compared to B1-c.

Option C

The two route option combinations containing Section C/D and C1, Options 17 and 35, performed very well in the Social and Economic silo and in the Safety and Functionality silo, and using Method 2 were ranked 16th overall with T1, and 10th overall with T2. However, the two route option combinations containing Sections C/D and C1 performed worst of all options (i.e. ranked 36th with T1 and 35th with T2) in the Natural and Cultural Environment silo and therefore fell short of meeting the Method 1 principle aimed at balanced performance across the three silos. The reasons for the poor performance in the Natural and Cultural Environment silo were high impacts, and therefore low scores in terrestrial ecology, aquatic ecology, heritage, and landscape and visual evaluation criteria.

Option C has therefore been eliminated based on its poor performance compared to other options.

Option D

Section D1, which is part of Options 18 and 36, is the only section besides A1-c that is not included in options that fulfil the selection principles for either Method 1 or 2. Options 18 and 36 performed poorly in the Safety and Functionality silo (ranked 35th and 26th respectively) and therefore did not meet the principle of balanced performance across the three silos. The reasons for the poor performance in this silo were the longer length reducing travel efficiency, and construction risks associated with lengths of structures, soft soils and acid sulphate soils. While Options 18 and 36 performed very well in the Social and Economic silo (mainly due to low residential, noise and lifestyle impacts), performance in the Natural and Cultural Environment silo was average to poor because of terrestrial ecology and heritage impacts. The effect when averaging performance across the three silos using Method 2 was that there were many other options with a better overall ranking.

Option D has therefore been eliminated based on its poor performance compared to other options.

6.7 Comparison of Top Performing Options

Based on the identification of the top performing options (see **Table 6.5**) and the confirmation of the elimination of the poor performers, seven options containing Sections A/B, A1-b, A1-a, B1-a, A1-b, B1-b, B1-c, A2, B2, T1 and T2 were selected for further evaluation. These options are shown in **Figure 6.5** and **Figure 6.6**.

Table 6.5 Seven Top Performing Options with Scores and Rankings by Silo

Option	7	8	15	23	25	26	33
Sections	A/B	A/B	A/B	A/B	A/B	A/B	A/B
	A1a	B1a	A1a	B1a	A1a	B1a	A1a
	B1b	B1b	B1b	A1b	B1b	B1b	B1b
	B1c	B1c	B1c	B1c	B1c	B1c	B1c
	A2	A2	B2	A2	A2	A2	B2
	T1	T1	T1	T2	T2	T2	T2
Safety & Functionality							
Sum of Weighted Scores	3.52	3.68	3.56	3.37	3.89	4.06	3.93
Ranking of Weighted Scores (out of 36)	**16**	**11**	**15**	**20**	**7**	**2**	**6**
Social & Economic							
Sum of Weighted Scores	2.75	2.99	3.08	2.78	2.64	2.88	2.97
Ranking of Weighted Scores (out of 36)	**18**	**10**	**9**	**16**	**22**	**14**	**12**
Natural & Cultural Environment							
Sum of Weighted Scores	4.14	4.07	4.02	4.14	4.14	4.08	4.02
Ranking of Weighted Scores (out of 36)	**4**	**12**	**18**	**5**	**3**	**11**	**17**
Average of Rankings for the 3 Silos	12.7	11.0	14.0	13.7	10.7	9.0	11.7
Rank of Average Ranking (out of 36)	**6**	**3**	**8**	**7**	**2**	**1**	**4**

As shown in **Table 6.5**, the top performing options differ in four sections. This results in a choice between the following:

- A1-a and B1-a.
- A1-b and B1-b.
- A2 and B2.
- T1 and T2.

Figure 6.5 Top Performing Options (Numbers 7, 8, 15 and 23)

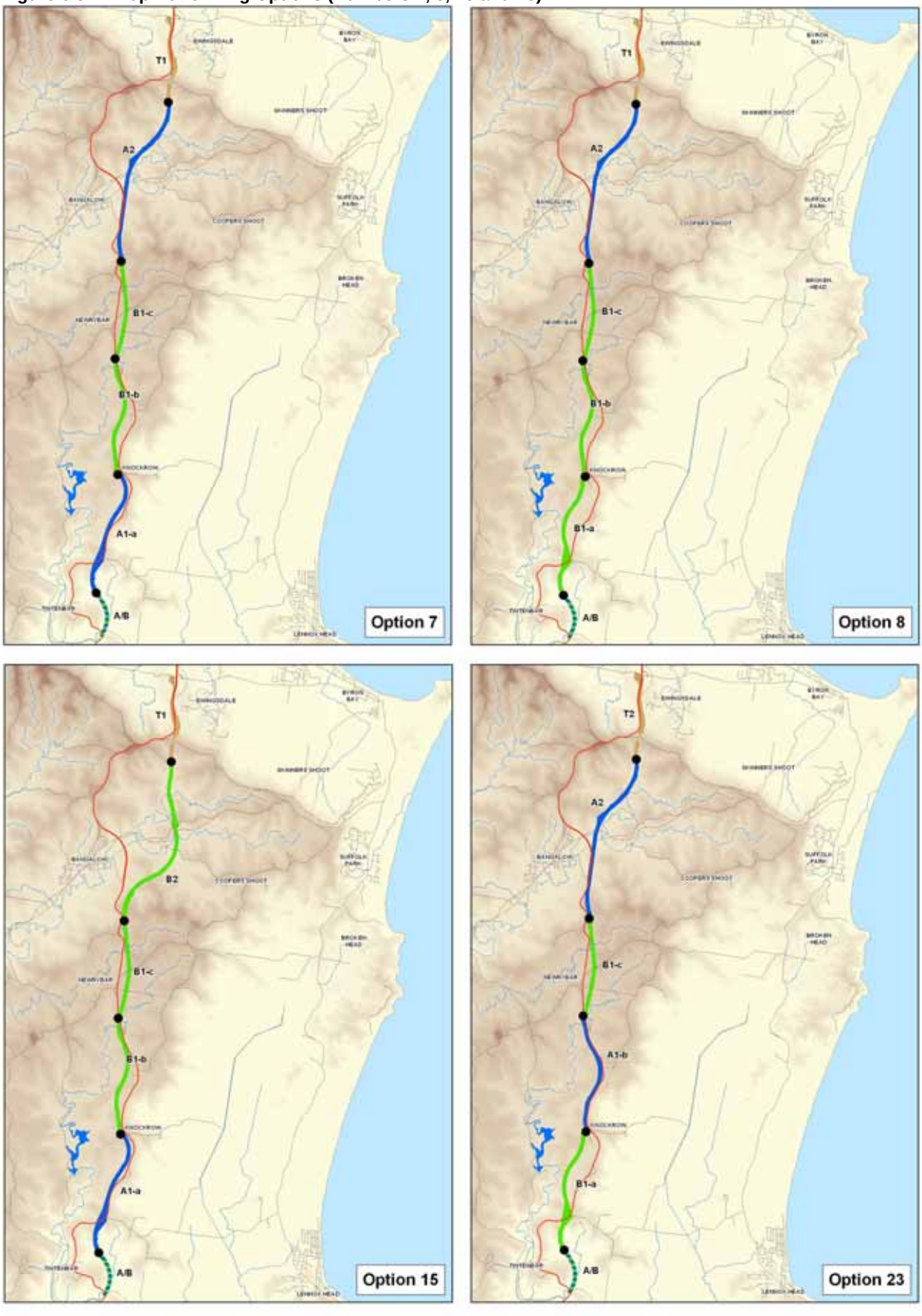


Figure 6.6 Top Performing Options (Numbers 25, 26 and 33)

6.7.1 Comparison Between A1-a and B1-a

By comparing Option 7 with 8 and Option 25 with 26, the relative performance of Subsections A1-a and B1-a can be evaluated.

In terms of technical performance, there is little to separate A1-a from B1-a. B1-a performs better in the Safety and Functionality silo and in the Social and Economic silo; but A1-a performs better in the Natural and Cultural Environment silo, primarily because it is further from Emigrant Creek Dam and Killen Falls and has a lesser impact on existing drainage patterns.

On balance, and while the overall differences are small, there is a marginal preference for Subsection A1-a over B1-a because it more closely matches the Ballina Bypass EIS design and allows full use of land already acquired by RTA for the Ballina Bypass.

6.7.2 Comparison Between A1-b and B1-b

The performance of these subsections can be evaluated by comparing route option combinations that are identical except for A1-b or B1-b. For example, Option 26 (containing B1-b) can be compared to Option 23 (containing A1-b). In terms of the overall ranking when combining silos, B1-b performs better than A1-b because it provides a better balanced performance than A1-b across the three silos.

The difference between the two subsections is most pronounced in the Safety and Functionality silo where options containing B1-b perform much better because there are fewer topographical constraints on B1-b and higher safety and geometric standards can be achieved.

Overall there is a preference for B1-b over A1-b.

6.7.3 Comparison Between A2 and B2

By comparing Option 7 with 15 and Option 25 with 33 the relative performance of Sections A2 and B2 can be evaluated.

In terms of technical performance, there is little to separate A2 from B2. B2 performs slightly better in the Safety and Functionality silo and in the Social and Economic silo, but A2 performs better in the Natural and Cultural Environment silo. Options 25 and 33 are ranked 2nd and 4th overall while Option 7 is ranked 6th overall compared to Option 15 as 8th overall.

On balance, Section A2 is preferred because of its slightly better overall performance and because it utilises both the 9(a) proposed road reserve zone and almost half of the existing Bangalow Bypass.

6.7.4 Comparison Between T1 and T2

By comparing Option 7 with 25, Option 8 with 26, and Option 15 with 33 the relative performance of T1 and T2 can be evaluated.

In terms of technical performance, the main difference is that T2 performs appreciably better in the Safety and Functionality silo, primarily because of the flatter grade on the north side of the tunnel. There is little to differentiate the two options in the other two silos. The small technical advantage of T2 is also apparent when considering the performance of the two segments by averaging the silo rankings using Method 2. T2 performs better overall compared to T1, improving the overall ranking by several positions in each comparison.

Tunnel option T2 is closer to Ewingsdale by up to 50 m and would result in slightly higher average noise levels for Ewingsdale before consideration of noise mitigation measures (appropriate noise mitigation would achieve the same L_{eq} noise results for T1 and T2 as noted in *Pacific Highway Upgrade, Tintenbar to Ewingsdale, Noise Working Paper* [RTA 2006]). The flatter grade associated with T2 does however offer better potential for future average noise reduction as engine technology improves, particularly in relation to engine braking.

On balance, and while the differences are small, there is a marginal preference for tunnel option T2 for the following reasons:

- Flatter grades of T2 would allow ongoing savings in travel costs, accident costs and fuel usage, with flow on benefits in terms of greenhouse gas emissions.
- T2 would be slightly easier to construct as the merge to the existing highway would occur at a location where traffic management during construction would be less complex and safer.

6.8 Outcomes of Technical Assessment

The results of the technical comparisons are:

- Options A and B perform better than Options C and D.
- Combinations of subsections for A1and B1 perform better than A1 and B1 as stand alone sections.
- A1-a performs similarly to B1-a but there is a preference for A1-a because it more closely matches the Ballina Bypass EIS design and allows full use of land already acquired by RTA for the Ballina Bypass.
- B1-b performs better overall compared to A1-b and is preferred.
- A2 is preferred over B2 as it utilises both the 9(a) proposed road reserve zone and almost half of the existing Bangalow Bypass.
- T2 performs marginally better overall compared to T1 and is preferred.
- In summary, the preferred route option resulting from the technical assessment includes: A/B, A1-a, B1-b, B1-c, A2 and T2

7 Recommendation of the Preferred Route

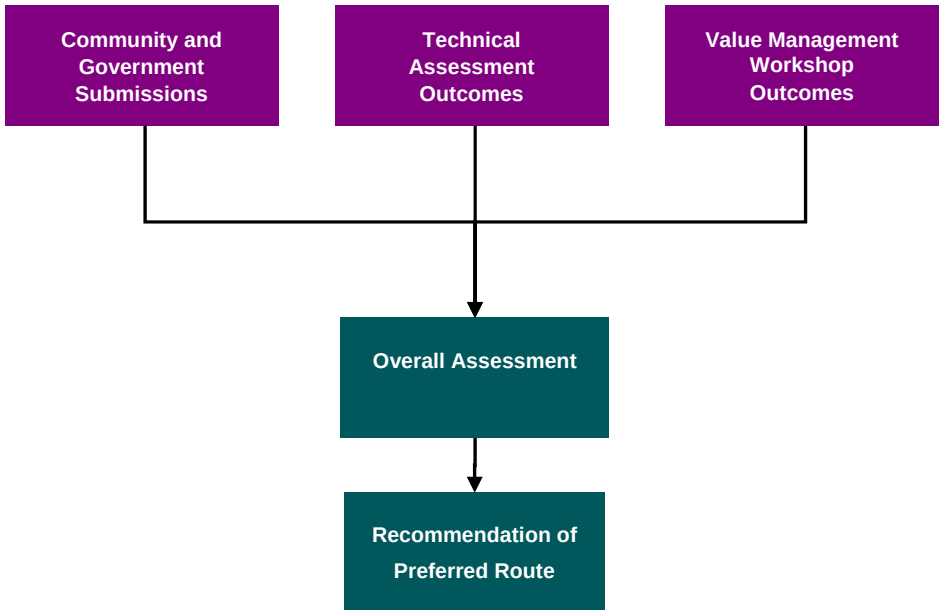
7.1 Methodology

The recommendation of the preferred route is an outcome based on the results of three independent 'streams' of work conducted on the Tintenbar to Ewingsdale Pacific Highway Upgrade. These three streams are:

- Community and agency submissions on the Route Options Display held in late 2005 and the corresponding RODR, as reported in the *Route Options Submissions Report* and summarised in **Chapter 4**.
- The VMW for the short list of route options held in December 2005 as reported in the *Value Management Workshop Report* and summarised in **Chapter 5**.
- The technical assessment of the short list of route options as reported in this document, PRR, **Chapter 6**.

The Project Team conducted an overall assessment of the short list of route options by comparing the outcomes of the three streams and considering costs and value for money. This process is outlined in **Figure 7.1** and the results are documented in this chapter.

Figure 7.1 Process for Recommending Preferred Route



7.2 Differences in Analysis Base by Stream

When comparing the outcomes of the three streams of work conducted on the Tintenbar to Ewingsdale Pacific Highway Upgrade, it is important to note there are some differences in the analysis base for each of the streams, including:

- The community/agency submissions were based on the RODR information and individual local knowledge.
- The VMW used the RODR information updated by some additional information collected by the Project Team following the publication of the RODR. At the VMW, evaluation criteria were developed and analysed in four separate silos: Functional, Economic, Social, and Natural and Cultural Environment.

- The technical assessment reported in **Chapter 6** of this document uses the latest information for footprints, including information collected and analysed following the VMW. It considers the comparative merits in three silos of evaluation criteria: Safety and Functionality, Social and Economic, and Natural and Cultural Environment; these categories are the same as the VMW except that social and economic are combined. The technical assessment is based on the Sieve 2 evaluation criteria; these criteria are generally a refinement of the Sieve 1 criteria used to determine the short list of route options in the RODR.

7.3 Key Outcomes of the Three Streams

The key outcomes of the three streams are summarised as follows:

- Community and Agency Submissions
    - Options A and B were favoured over Options C and D.
    - Option A was preferred over Option B.
    - T2 was preferred over T1.
    - No conclusive results could be drawn on preference for sections (i.e. A2 over B2).
- Value Management Workshop
    - Option C was clearly the worst performing option and Section C1 should not be considered further.
    - Option B2 was also a poor performing section and should not be considered further.
    - Option D was considered marginal.
    - T1 and T2 were seen to be similar.
- Technical Assessment
    - Options A and B perform better than Options C and D.
    - Combinations of subsections for A1 and B1 perform better than A1 and B1 as stand alone sections.
    - Poor performing options and sections that were eliminated from further consideration include: Options C and D, and Subsection A1-c.
    - The top performing options include: A1-a, B1-a, A1-b, B1-b, B1-c, A2, B2, T1 and T2.
    - The top performing options differ in four areas: A1-a and B1-a; A1-b and B1-b, A2 and B2; and T1 and T2.
    - A1-a is preferred over B1-a.
    - B1-b is preferred over A1-b.
    - A2 is preferred over B2.
    - T2 is preferred over T1.

7.4 Comparison of Outcomes of the Three Streams

Comparison of the outcomes from the three streams provides the following results as shown in **Table 7.1**:

- Options A and B are preferred over Option C in all streams.
- Options A and B are preferred over Option D in two streams.
- A2 was preferred in one stream, and B2 was a poor performing option in one stream.
- T2 was preferred in two streams, and considered similar to T1 in one stream.

Table 7.1 Outcomes of the Three Streams

Options	Community and Agency Submissions*	Value Management Workshop	Technical Assessment
Options A, B, C and D	A and B preferred over C and D	C was the worst performing option and there was uncertainty regarding D	A and B preferred over C and D
A2 and B2	No definitive results	B2 performs poorly and should not be considered further	A2 preferred over B2
T1 and T2	T2 was preferred over T1	T1 and T2 considered similar	T2 preferred over T1

*Based on submissions received on the Route Options Display and the RODR.

7.5 Overall Assessment

The overall assessment of the short list of route options considers the results of the three streams in combination with cost and value for money considerations. The results of this assessment are described in the following sections.

7.5.1 Cost Comparison

A cost comparison of all the shortlisted route option combinations is provided in **Table 3.16.** **Table 7.2** provides a summary of the cost of the top performing options discussed in **Section 6.7** and provides the basis for a value for money comparison of these options. By reviewing option combinations that vary by only one section, the cost difference of the two varying sections can be determined. The key results of the cost comparison are:

- Cost estimates for Options C and D are significantly higher than estimates for Options A and B (see **Table 3.16,** Options 17, 18, 35, and 36).
- Options incorporating B1-a are about $5 million more expensive than similar options incorporating A1-a (see **Table 7.2,** Options 7 and 8).
- Options incorporating A1-b are about the same cost as similar options incorporating B1-b (see **Table 3.16**, Options 14 and 15).
- Options incorporating B1-c are about $10 million less expensive than similar options incorporating A1-c (see **Table 3.16**, Options 2 and 5).
- Options incorporating B2 are about $43 million more expensive than options incorporating A2 (see **Table 7.2,** Options 7 and 15).
- Options incorporating T2 are about $12 million more expensive than options incorporating T1 (see **Table 7.2**, Options 7 and 25).

Table 7.2 Cost Comparison of Top Performing Options ($ million)

Option	7	8	15	23	25	26	33
Sections	A/B	A/B	A/B	A/B	A/B	A/B	A/B
	A1a	B1a	A1a	B1a	A1a	B1a	A1a
	B1b	B1b	B1b	A1b	B1b	B1b	B1b
	B1c	B1c	B1c	B1c	B1c	B1c	B1c
	A2	A2	B2	A2	A2	A2	B2
	T1	T1	T1	T2	T2	T2	T2
Comparative Cost Estimate	$373	$378	$416	$389	$385	$390	$428

7.5.2 Option C and Option D Assessment

Option C was the worst performing option in the VMW and it performed poorly in the technical assessment; additionally community and agency submissions generally preferred Options A and B over Option C.

Option D performed poorly in the technical assessment, and community and agency submissions generally preferred Options A and B over Option D. The VMW results regarding Option D were uncertain.

As previously noted, cost estimates for Options C and D are significantly higher than costs for Options A and B. The combination of poor performance and higher costs results in low value for money considerations.

In summary, Options C and D perform poorly compared to Options A and B and should not be considered further.

7.5.3 A1 and B1 Assessment

The technical assessment identified that combinations of subsections for A1 and B1 perform better than A1 and B1 as stand alone sections. Further assessment of Sections A1 and B1 has therefore been carried out on a subsection basis as described below.

A1-a versus B1-a Assessment

Subsections A1-a and B1-a were not directly compared in the community and agency submissions or at the VMW, but potential impact on Emigrant Creek Dam was an area of concern raised in both streams.

In terms of the technical assessment, A1-a performs similarly to B1-a. As noted in **Section 6.7.1**, A1-a has lower natural and cultural environment impacts, primarily because it is further from Killen Falls and Emigrant Creek Dam. In addition, it more closely matches the Ballina Bypass EIS design and allows full use of land already acquired by the RTA for the Ballina Bypass. A1-a is also about $5 million less expensive than B1-a. On the basis of similar performance at a lower cost, A1-a provides greater value for money than B1-a.

Compared to B1-a, A1-a performs similarly in the technical assessment, better addresses issues raised in the other two streams, and provides greater value for money. In conclusion, A1-a is the preferred section.

A1-b versus B1-b Assessment

Subsections A1-b and B1-b were not directly compared in the community and agency submissions or at the VMW, but potential impacts on high value agriculture and Emigrant Creek were areas of concern raised in both streams.

In terms of the technical assessment, Section B1-b performs better than A1-b, particularly in terms of safety (see **Section 6.7.2**) and has a similar cost. On the basis of better performance at a similar cost, B1-b provides greater value for money.

A1-c Versus B1-c Assessment

Subsections A1-c and B1-c were not directly compared in the community and agency submissions or at the VMW, but potential impacts on Newrybar and the Newrybar school were areas of concern raised in both streams.

In terms of the technical assessment, B1-c performs much better than A1-c, and none of the route options with A1-c were included in the top performing options. B1-c also costs about $10 million less than A1-c, thus B1-c provides greater value for money.

B1-c performs better in the technical assessment and better addresses key issues raised in the other two streams. In conclusion, B1-c is the preferred section.

7.5.4 A2 versus B2 Assessment

A key outcome of the VMW was the recommendation that Section B2 should not be considered further.

Results of the technical assessment indicate that A2 and B2 are very similar (see **Section 6.7.3**), thus the only significant difference is the relative cost. A2 is significantly less expensive than B2, by about $43 million, mainly due to the higher structure costs in B2. Additionally, A2 utilises the 9(a) proposed road reserve zone and almost half of the existing Bangalow Bypass On the basis of similar performance at a much lower cost, A2 provides greater value for money.

Selection of A2 over B2 is consistent with the results of two of the streams and value for money considerations. In conclusion, A2 is the preferred section.

7.5.5 T1 versus T2 Assessment

While the performance of T1 and T2 were considered similar in the VMW, T2 was generally preferred in the community and agency submissions. In the technical assessment of T1 and T2, T2 was preferred based on a small performance advantage (see **Section 6.7.4**).

T2 is more expensive than T1 by about $12 million; however T2 provides benefits which off-set the additional capital costs. These benefits include:

- Lower grades providing ongoing benefits over the project life in travel time savings, accident reduction, fuel savings and reduced greenhouse gas emissions.
- Less complex construction and traffic management, thus easier and safer to build.

Considering the results of the three streams and the above benefits, the additional cost of T2 is considered justified in terms of value for money considerations. In conclusion, T2 is the preferred section.

7.6 Recommendation of Preferred Route

Based on the comparison of the outcomes of the three streams and value for money considerations, the recommended preferred route (see **Figure 8.1**) is the option made up of: **A/B, A1-a, B1-b, B1-c, A2 and T2**. This route was selected for the following key reasons:

- Provides the best overall balance between functional, ecological, heritage, social, and economic considerations and provides for staging opportunities.
- Best meets the objectives of both the Pacific Highway Upgrade Program and the Tintenbar to Ewingsdale project.
- Achieves high safety standards.
- Provides for grade separation of the upgraded Pacific Highway and the local road system.
- Provides a good outcome in terms of transport efficiency.
- Provides reasonable physical separation from existing and proposed major residential areas such that acceptable visual and traffic noise outcomes could be achieved with sensitive urban design.
- Considers the outcomes of the VMW and community submissions.
- Allows for potential water quality risk reductions in the Emigrant Creek Dam area.
- Provides good road user benefits for a reasonable construction cost.
- Retains 'Macadamia Castle', a local landmark.
- Retains the existing highway as a local/tourist road.
- Has a lower impact on the escarpment and visual amenity compared to coastal options.
- Utilises the highest amount of existing and planned highway reserves (Ballina Bypass, 9(a) proposed road reserve zone and Bangalow Bypass).
- Avoids known aboriginal heritage sites.
- Avoids State significant agricultural land.
- Has a lower impact on EEC's compared to coastal options.
- Has a lower risk associated with soft soils, flooding and land slips compared to coastal options.
- Has the minimum impact on wildlife corridors compared to other options.
- The T2 tunnel has reduced travel time, lower greenhouse gas emissions, and less road user costs than the T1 tunnel.
- Impacts on agricultural properties could be reduced, where possible, through discussions with individual land owners and refinement of the design.

7.7 Preferred Route Summary

The preferred route consists of sections A/B, A1-a, B1-b, B1-c, A2, and T2. This route is on the plateau and uses the approved alignment of the northern section of the Ballina Bypass, the 9(a) proposed road reserve zone and the southern half of the Bangalow Bypass.

The alignment of the route south of the Bangalow Bypass is near to the existing Pacific Highway alignment but not coincident. North of the Bangalow Bypass, the route traverses farmland to the tunnel under St Helena Road. From the tunnel to the Ewingsdale interchange, the route is immediately to the east of the existing Pacific Highway but at a considerably flatter grade and a much lower level. The preferred route is described in detail in **Chapter 8**.

8 The Preferred Route

8.1 Description of the Preferred Route

The preferred route, shown in **Figure 8.1**, commences at Sandy Flat Road and extends north approximately 23 km to the existing Ewingsdale interchange. This chapter provides a description of the preferred route, including:

- A section by section overview, including engineering and design characteristics.
- Traffic and transport characteristics.
- Geotechnical and hydrological characteristics.
- Planning and land use characteristics
- Socio-economic characteristics.
- Environmental characteristics, including water quality, aquatic and terrestrial and ecology, cultural heritage, noise and air quality characteristics.

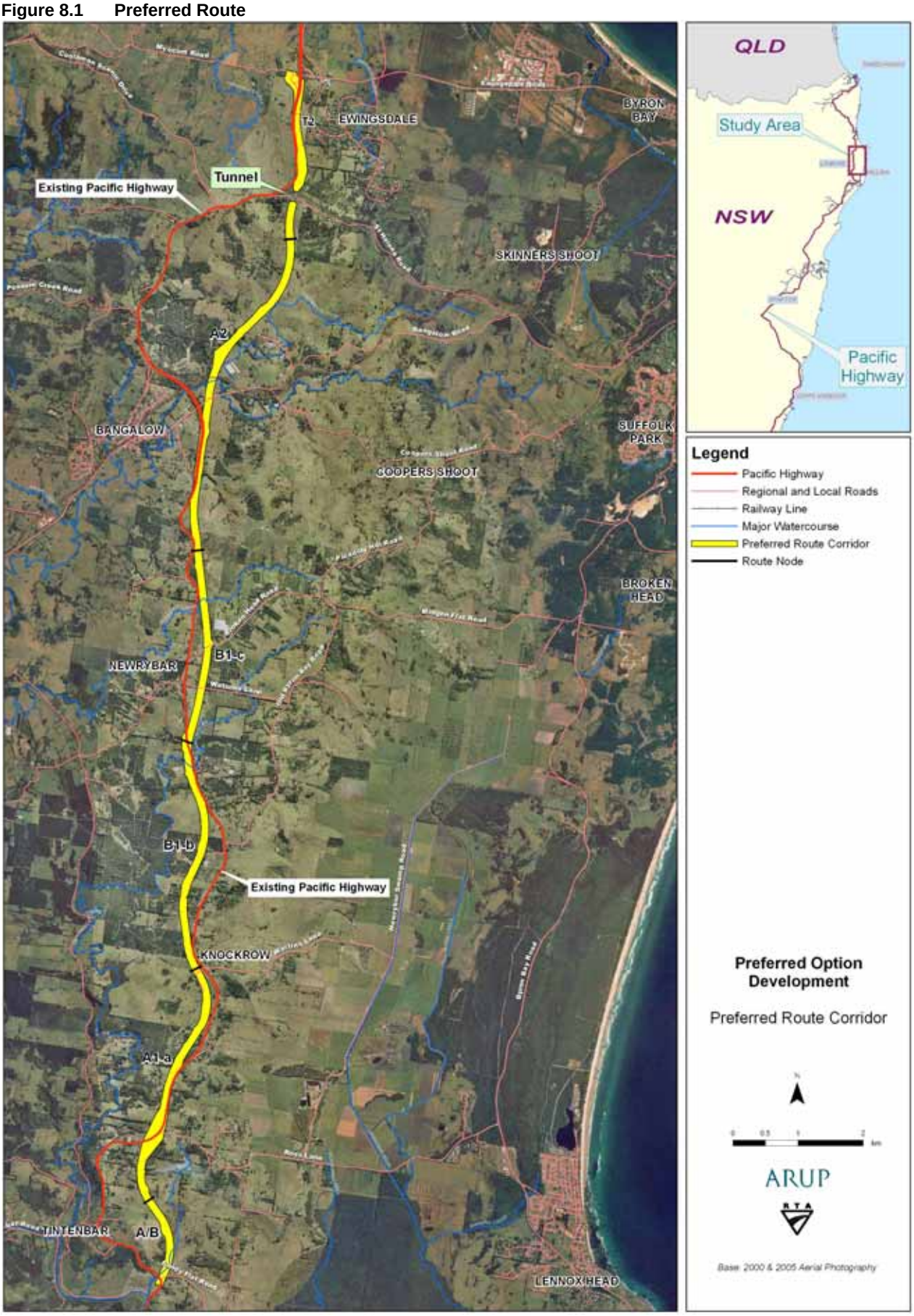
In many instances, the information in this chapter summarises more detailed information on the preferred route contained in the working papers that are referenced in this chapter.

The impacts described in this chapter are based on the footprint of the preliminary concept design. The footprint is indicative of the likely actual road reserve width requirements and includes the land that would be required for the physical roadway (highway and service roads), public utility plant (if required), earthworks, and maintenance clearances. The footprint also includes a margin for drainage or other works that may be required beyond the extent of earthworks. The preliminary concept design will continue to be refined and where possible, impacts of the footprint will be reduced. Preferred route figures in this chapter reflect the 'preferred route corridor', not footprints. This corridor allows a margin for future design refinement.

Throughout this chapter, the term 'directly affected' is used to describe impacts where the area or structure being discussed is located within (or 'under') the footprint of the preferred route (whether it is a dwelling or a patch of vegetation).

The sections of the preferred route are shown, from south to north, in **Figure 8.2**, **Figure 8.3**, **Figure 8.4, Figure 8.5** and **Figure 8.6.**

Figure 8.1 Preferred Route



8.2 Overview of the Preferred Route by Section

8.2.1 Section A/B

This section utilises the approved Ballina Bypass corridor with some minor amendments to the geometry so that it now meets the current design standards. The height of fill in the soft soil areas has also been reduced. The alignment adjustments have been designed to ensure the preferred route remains inside the land already purchased and under negotiation.

8.2.2 Section A1-a

This section includes the northbound climb up the southern escarpment with a grade of 5.9% over about 1.5 km. It contains the Ross Lane interchange which is similar in layout to that proposed as part of the Ballina Bypass. However, the alignment has been moved slightly west so that the existing highway can be retained as a local road on the east side of the preferred route. South of the interchange the alignment remains inside land acquired for the Ballina Bypass but north of the interchange, additional land will be required on the west side.

The interchange is a diamond layout type with a roundabout located on each side at the ramp terminations. The roundabout on the west side connects to the existing highway providing local access to the south while the roundabout on the east side connects to Ross Lane and to the existing highway providing local access to the north. The two roundabouts would be connected by a bridge above the preferred route. The interchange has four ramps and provides for movements in all directions.

The alignment north of the interchange follows a corridor just to the west of the existing highway. The alignment avoids the residential clusters near Knockrow and also passes just to the west of the Rous Water reservoir on the hill opposite Knockrow. It keeps as close to the existing highway as possible, while complying with minimum design standards and avoiding the Rous Water facility. Following the existing highway as closely as possible also reduces the impact on agricultural properties which generally extend from the existing highway all the way back to Emigrant Creek and the dam. The alignment in this section is subject to review following discussions with property owners.

An access road would be provided on the west side with an underpass located between Knockrow and Martins Lane providing a link to the existing highway. Houses on the east side of the preferred route would retain their access to the existing highway.

8.2.3 Section B1-b

From Martins Lane the preferred route diverges to the west, avoiding any direct impact on Macadamia Castle and achieving a higher standard of geometric alignment than would be possible following the existing highway corridor.

North of Macadamia Castle, the preferred route runs parallel to and west of the existing highway for about 600 m and then merges back to a corridor located just west of the existing highway. South of Hambly Lane, the preferred route crosses an unnamed creek on twin bridge structures approximately 90 m long and crosses Emigrant Creek on twin bridges structures approximately 120 m long.

An access road would be provided on the west side with a link back to the underpass in A1-a just south of Martins Lane. At Ivy Lane, a bridge would be provided over the upgraded highway to provide access to the west side of the preferred route for those properties between Macadamia Castle and the Emigrant Creek crossing. Houses on the east side of the preferred route would retain their access to the existing highway which would remain as a local road.

8.2.4 Section B1-c

Between Hambly Lane and Watsons Lane, the preferred route crosses to the east side of the existing highway. The preferred route passes underneath the existing highway and the existing highway would be reconstructed on a bridge, approximately 150 m long, above the preferred route. The preferred route passes over Watsons Lane about 300 m east of Newrybar. An underpass would be provided to allow access for local traffic.

The alignment diverges to the east of both Newrybar and the school so that these two entities are not separated. On the north-east side of the school, the alignment passes underneath Broken Head Road in a cutting about 12 m deep. Broken Head Road would pass above the preferred route on a bridge about 130 m long, providing continued access to Newrybar, the school and the existing highway. There would be no direct connections between Broken Head Road and the preferred route.

North of Broken Head Road, the alignment moves back towards the existing highway, crossing Skinners Creek on twin bridges about 120 m long before merging onto the 9(a) proposed road reserve zone that is designated for highway usage. Section B1-c ends at the top of the hill, reaching an elevation of about 120 m above sea level, the highest point on the preferred route.

There is no requirement for an access road on the east side through this section. All houses and properties to the west of the preferred route would retain their access to the existing highway which would remain as a local road.

8.2.5 Section A2

The preferred route follows the 9(a) proposed road reserve zone to the east of the existing highway, avoiding the tight curves and steep grades of the existing highway. A local access connection would be provided mid-way through the 9(a) proposed road reserve zone. A bridge above the upgraded highway would provide a connection between the existing highway and properties to the east of the preferred route.

Just north of the crest of the hill the alignment is in a cutting up to 30 m deep before descending at a grade of 5.3% for a length of over 1 km. The alignment continues along the 9(a) proposed road reserve zone before connecting onto the southern end of the Bangalow Bypass. The northbound carriageway of the Bangalow Bypass would be converted to a two-way local road while the southbound carriageway would become the northbound carriageway of the preferred route. A new southbound carriageway for the preferred route would be constructed on the east side of the existing Bangalow Bypass.

Through this section a local access road would be provided on the east side of the preferred route to provide access to several properties on the east side.

Just south of Bangalow Road, the preferred route diverges to the east, away from the Bangalow Bypass. Twin bridges, about 30 m long, would be provided above Bangalow Road and longer twin bridges, about 175 m long, would be provided above Byron Creek and the railway line on the north bank of the creek. The alignment then follows Tinderbox valley, remaining on the west side of Tinderbox Creek.

An underpass would be provided to maintain local access to Tinderbox Road, but no frontage roads would be required through this section which ends about 500 m south of the tunnel portal.

8.2.6 Section T2

The preferred route goes through a tunnel approximately 250 m long and about 45 m below St Helena Road. Twin tunnels separated by a rock pillar are proposed. A separate tunnel would be provided for each carriageway. Preliminary geotechnical investigations indicate that the tunnel would be through the Lismore Basalt which generally comprises competent high strength basalt separated by more weathered and fractured basalt layers. Tunnel excavation would use conventional drill and blast techniques. Preliminary studies have concluded that the tunnel is not expected to significantly affect the existing groundwater regime and therefore a drained (unlined) tunnel is proposed.

On the north side of the tunnel, the preferred route is aligned just to the east of the existing highway such that the existing highway can be retained as a local road. The alignment runs as close as possible to the existing highway before merging onto the existing highway just south of the existing Ewingsdale interchange. The grade is 4.4% over a length of about 1.5 km. Where the preferred route passes the Ewingsdale residential area, it is lower and slightly closer to Ewingsdale than the existing highway.

South of Ewingsdale, a local access road would be required on the east side of the preferred route to provide access to properties on the east side.

As the preferred route merges onto the existing highway, the local access road would diverge to the west and a new connection road would connect this road to a new roundabout on the west side of the existing interchange. A new northbound off-ramp would be provided from the preferred route. In other respects the interchange would operate as it currently operates.

Figure 8.2 Preferred Route Sections A/B and A1-a

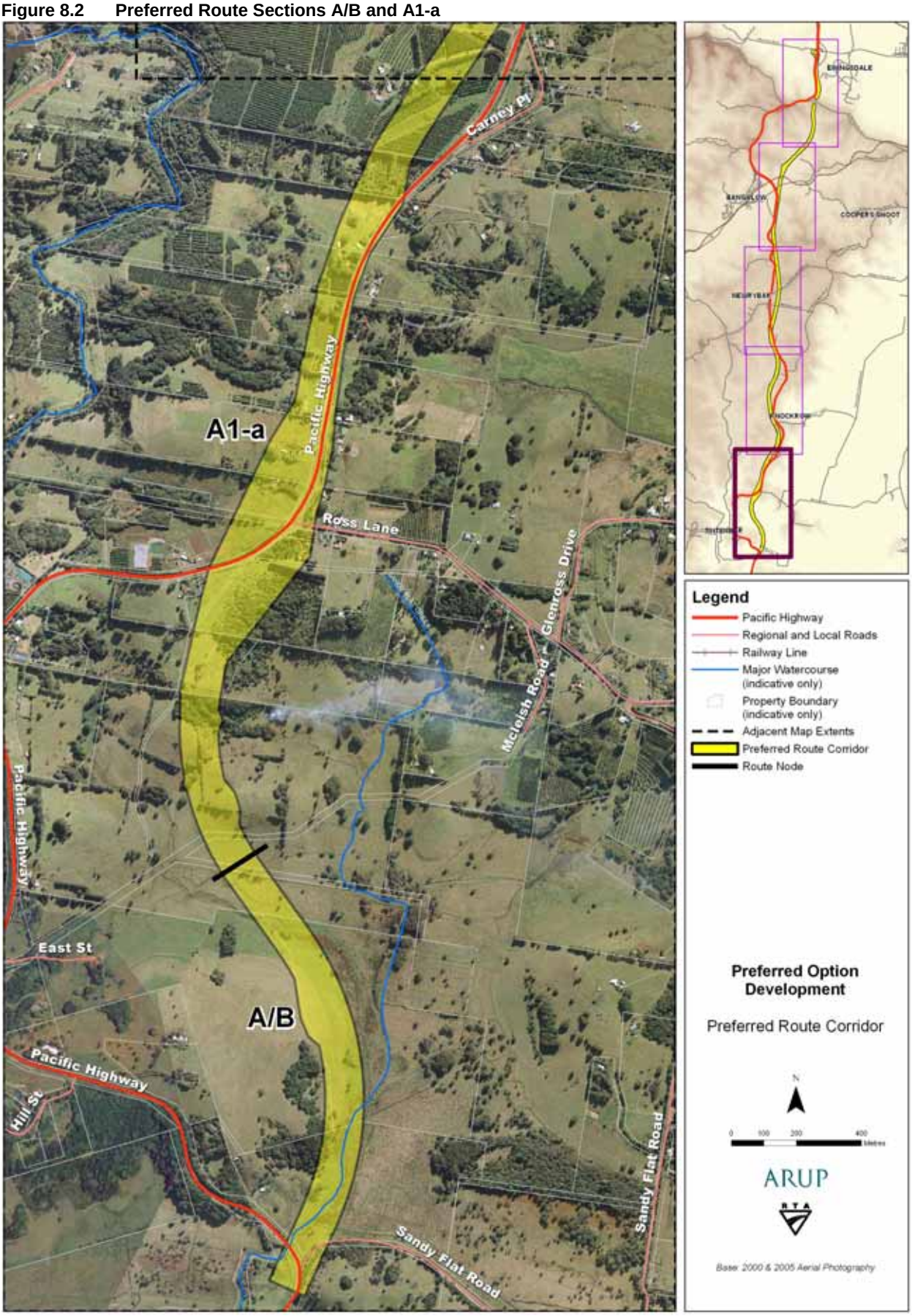


Figure 8.3 Preferred Route Sections A1-a and B1-b

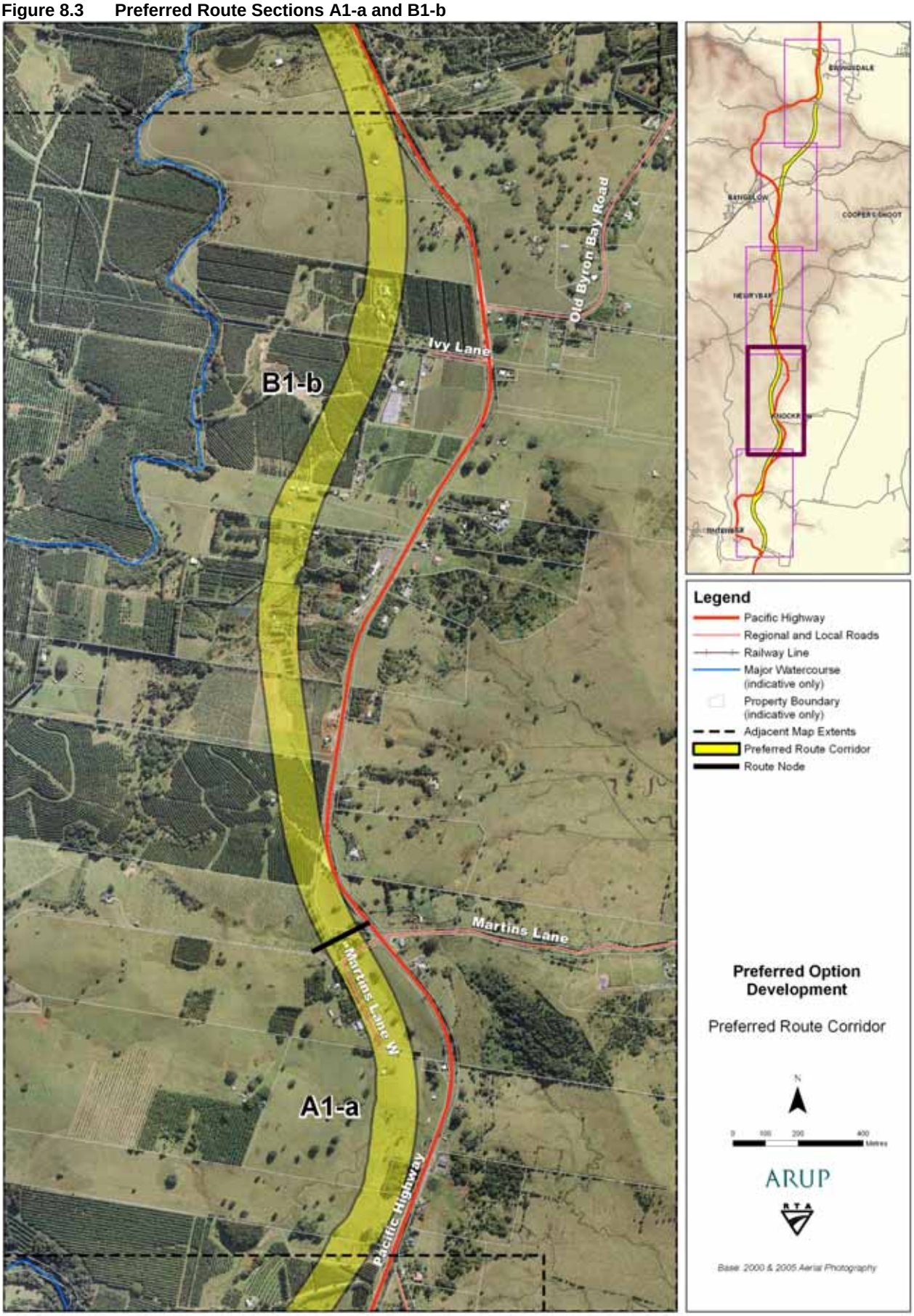


Figure 8.4 Preferred Route Sections B1-b and B1-c

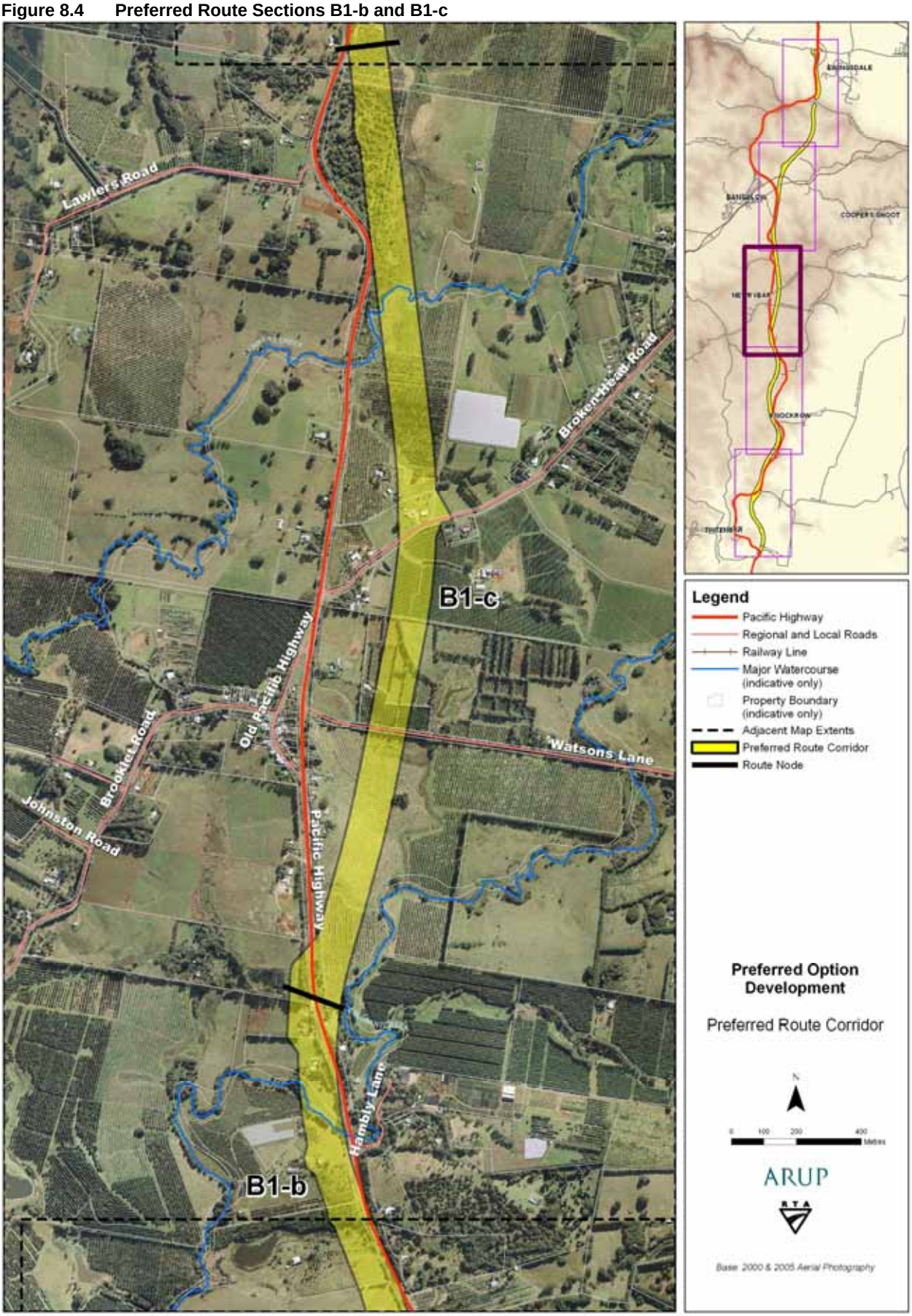


Figure 8.5 Preferred Route Section A2

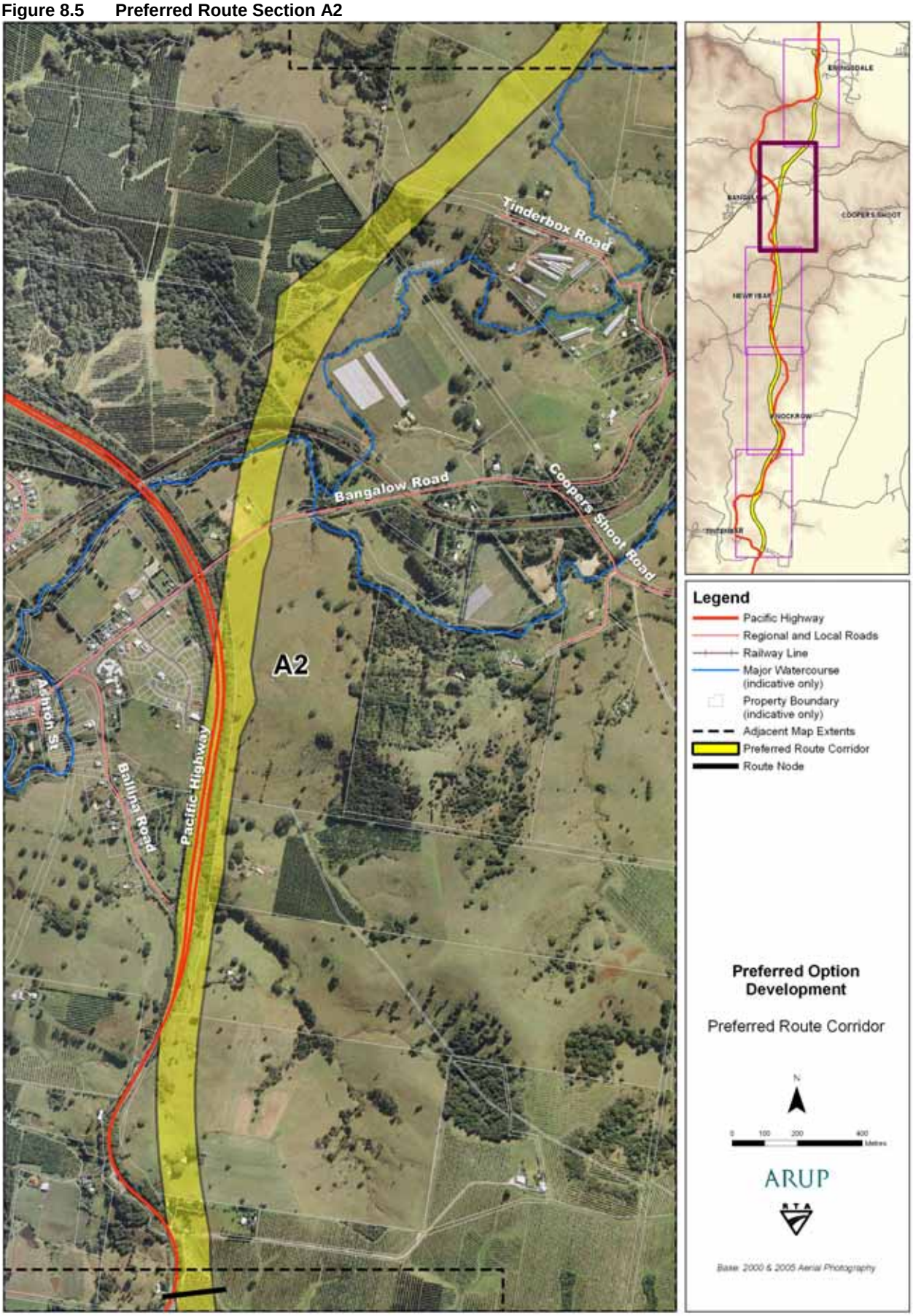
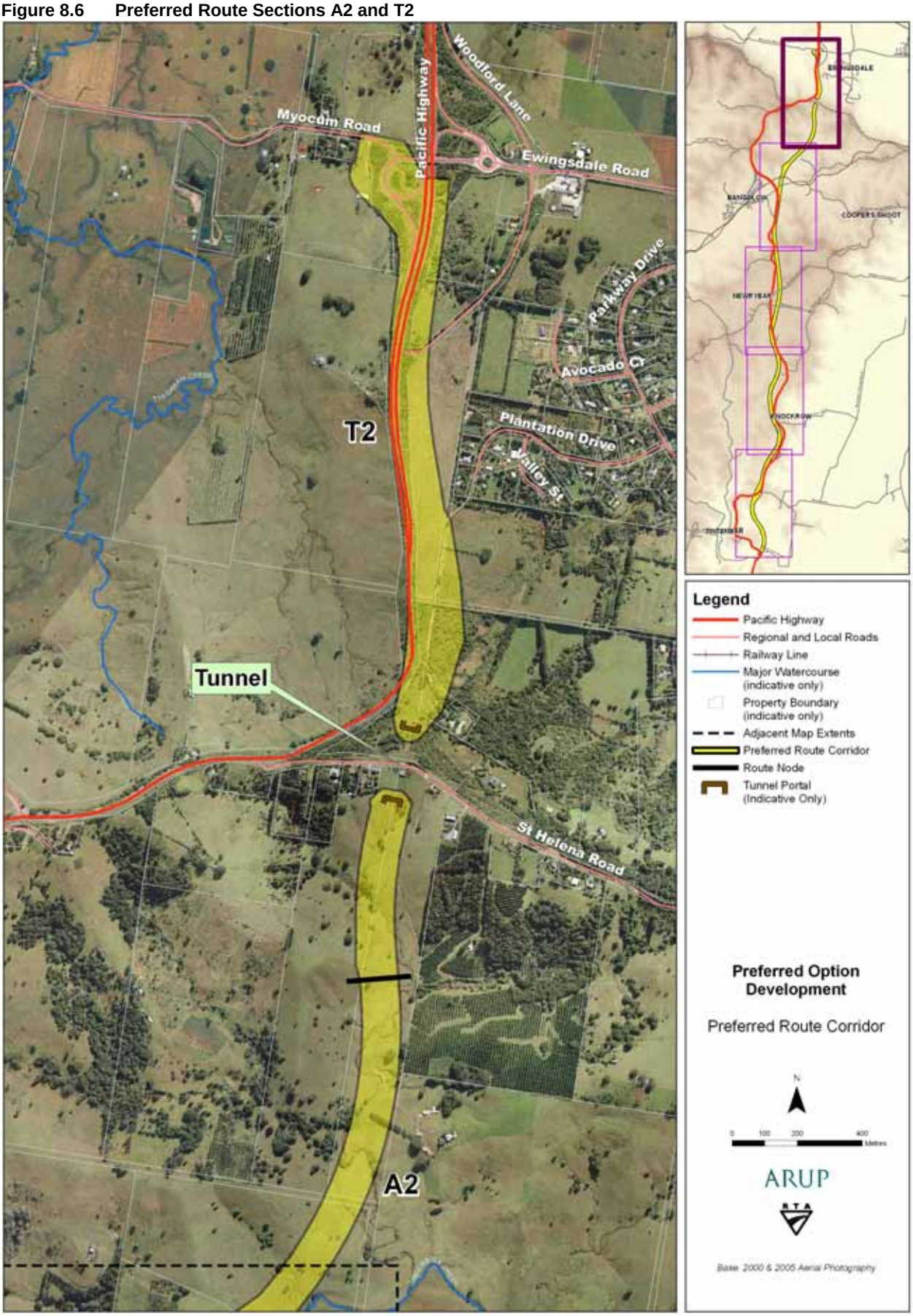


Figure 8.6 Preferred Route Sections A2 and T2



8.3 Traffic and Transport

8.3.1 Upgraded Highway Operation

The forecast traffic volumes (in vehicles) for the preferred route between 2006 and 2042 are detailed in **Table 8.1**. The table also shows the level of service achieved for the upgraded highway and indicates how sensitive this level of service is to changes in the predicted traffic volumes.

A linear growth rate of 3.2% has been used with an additional allowance for traffic diverted from other routes as various sections of the Pacific Highway are improved (including the approved Ballina Bypass). For the purposes of analysis, a predicted opening year of 2012 has been used. It should be noted however that this is a planning date and the actual year of opening would be dependent on the availability of funding.

Table 8.1 Forecast Traffic Volumes and Level of Service for Upgraded Highway

Forecast Year	Upgraded Highway AADV	Level of Service	Sensitivity Tests			
			-10% (2.9%)	Level of Service	+10% (3.5%)	Level of Service
2006	9,900	-	9,850	-	9,950	-
2012	12,600	B	12,350	B	12,850	B
2022	15,800	B	15,300	B	16,300	B
2032	18,700	B	17,900	B	19,500	C
2042	21,550	C	20,450	C	22,650	C

With two lanes in each direction, it is predicted that the preferred route between Tintenbar and Ewingsdale would operate at Level of Service B in 2012 and reach Level of Service C during 2033, 21 years after the nominal opening year 2012.

The sensitivity analysis indicates that with a 10% increase in traffic (equivalent to a linear growth rate of 3.5%) above the projected increase, the upgraded highway would still operate at Level of Service C in 2042, 30 years after opening.

Due to the traffic split between the preferred route and the existing highway, the proportion of heavy vehicles in the traffic stream would increase to around 17% or 2200 vehicles in 2012.

8.3.2 Interchanges

At the southern end of the project, a full diamond interchange would be provided at Ross Lane near the existing Pacific Highway/ Ross Lane intersection. The existing highway would be integrated with the interchange to allow direct access for vehicles entering or leaving the upgraded highway. As such, through vehicles on the existing highway would be required to travel through the interchange to continue north or south.

At the northern end of the project, the preferred route would connect to the existing Ewingsdale interchange.

8.3.3 Existing Highway Operation

Following construction of the upgraded highway, the existing Pacific Highway would become part of the regional road network. To the north of Bangalow, the existing highway would still carry significant traffic volumes. Traffic travelling to and from Lismore via Bangalow Road with origins and destinations outside of the study area would use the existing highway to access the upgraded highway at Ross Lane or the Ewingsdale interchange. **Table 8.2** shows the predicted traffic volumes on the existing Pacific Highway, after the proposed upgrade.

Table 8.2 Forecast Traffic Volumes for Existing Highway

Forecast Year	South of Bangalow		North of Bangalow	
	Existing Highway AADV	Level of Service	Existing Highway AADV	Level of Service
2006	3,200	-	8,500	-
2012	3,750	B	10,050	C
2022	4,750	B	12,600	C
2032	5,700	B	15,150	C/D
2042	6,650	B	17,750	D

Despite significant traffic volumes still using the existing highway north of Bangalow (with the preferred route), heavy vehicle traffic usage of the existing highway would be significantly reduced. B-doubles would be restricted from using the existing highway and other regional through truck traffic would choose to use the upgraded highway. The reduction of heavy vehicle traffic on the existing highway would be particularly noticeable at night-time when noise is a major concern.

Figure 8.7 shows the year 2012 expected hourly volumes on the existing highway north of Bangalow for both light and heavy vehicles. Currently just under 30% of daily heavy vehicles or approximately 640 heavy vehicles per day (2006) travel on the existing highway during the night-time hours of 10pm to 7am. This would drop to less than 20% or 140 heavy vehicles per day (2012) travelling at night on the existing highway.

Heavy vehicle proportions on the existing highway north of Bangalow would be similar to Bangalow Road west (around 8% of daily traffic) as traffic on the existing highway would comprise traffic connecting to and from Bangalow Road, as well as tourist and local traffic. Approximately 60% of all heavy vehicles (or just under 5% of total vehicles) would be rigid trucks of 3 axles or less. Heavy vehicle proportions south of Bangalow, where the forecast traffic volumes are lower, would be around 7% of daily traffic.

8.3.4 Reduction in Accidents

The overall accident rate on the preferred route is forecast to meet the project target of 15 accidents per 100 MVK travelled. The reduction in accidents compared to the existing Pacific Highway is achieved with the improved highway standard of the preferred route.

There is also an anticipated reduction in the number of accidents on the existing highway, after the upgrade, due to reduced traffic volumes. Accident rates per 100 MVK travelled on the existing Pacific Highway would also be reduced through:

- A reduction in speed limit, consistent with the design speed of the existing horizontal geometry.
- A reduction in the percentage and size of heavy vehicles.
- Greater consistency in the road environment between Bangalow to Ewingsdale and Bangalow to Lismore.
- Greater consistency in driver behaviour with the removal of ‘through’ traffic.

The preferred route offers a substantial annual reduction in the number of accidents between Tintenbar and Ewingsdale. The combined accident forecast for the preferred route and the existing highway is shown in **Table 8.3**. This combined forecast is very conservative as it assumes the current accident rate for the existing Pacific highway. As noted above, these rates are expected to improve; thus the number of accidents post-upgrade is likely to be less than those shown in **Table 8.3**.

Table 8.3 Forecast of Number of Accidents

Forecast Year	Accidents per year on existing highway (no upgrade)	Accidents per year on the preferred route and existing highway (post-upgrade combined)
2006	49	27
2012	58	34
2022	73	42
2032	88	50
2042	102	58

8.3.5 Local Access

Following the selection of the preferred route, the corresponding local road connections and service roads were reviewed. The local access arrangements that have been developed for the preferred route are illustrated in **Figure 8.8** and described below. Expected 2006 traffic flows for local roads as well as the preferred route and existing highway are shown in **Figure 8.9**.

From Sandy Flat Road to Ross Lane, the preferred route would be located to the east of the existing highway, and no existing local roads would be affected. North from Ross Lane the preferred route would be on the western side of the existing highway. Local service roads would be provided on the western side of the preferred route to connect severed properties to the Ross Lane interchange or the existing highway. Severed properties on the eastern side of the preferred route would maintain their current access to the existing highway.

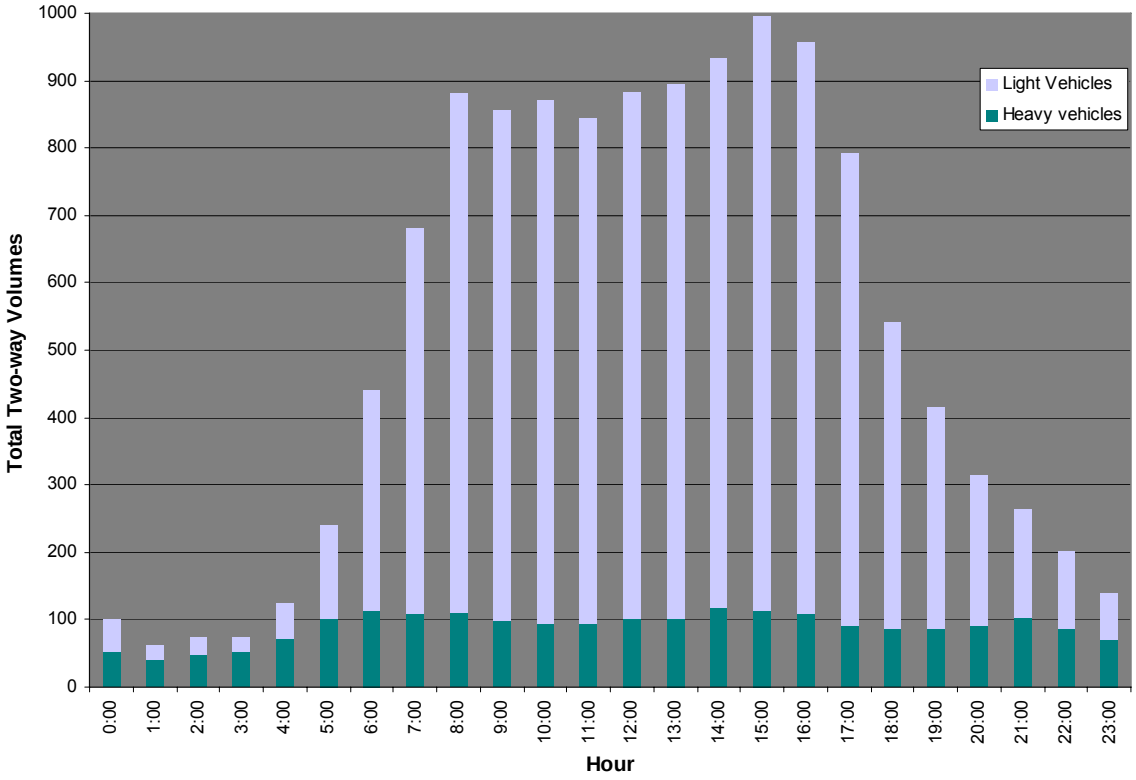
South of Newrybar (near Emigrant Creek), the preferred route would pass under the existing highway alignment and travel on the eastern side of the existing highway. An underpass would be provided at Watsons Lane to allow local traffic to pass under the upgraded highway. A bridge would be provided at Broken Head Road to allow local traffic to cross above the upgraded highway. The existing highway and the current property accesses to it would be maintained in this section.

The preferred route would utilise the southern section of the Bangalow Bypass dual carriageway, using the southbound carriageway as part of its alignment. Through this section, the northbound carriageway would become a two lane two-way local road. Where the preferred route diverges from the Bangalow Bypass to the north, a link and associated traffic management would be provided to connect the southbound carriageway to the northbound carriageway. A local road underpass would be provided at Bangalow Road to maintain this east-west connection. The existing Bangalow interchange would be maintained in its current form.

From north of Skinners Creek, small sections of local service road would be provided to link properties to the existing highway or to the nearest existing local road.

On the north side of the St Helena tunnel, the preferred route would be aligned just to the east of the existing highway and the existing highway would be retained as a local road. Where the preferred route merges onto the existing highway near Ewingsdale interchange, a new local access road would diverge west of the existing highway and connect to a new roundabout on the west side of the existing interchange. A new northbound off ramp would be provided from the preferred route. In other respects the interchange would operate as it currently operates.

Figure 8.7 Hourly Distribution of Traffic throughout a Typical Day
Preferred Route (2012)



Existing Pacific Highway (2012) North of Bangalow

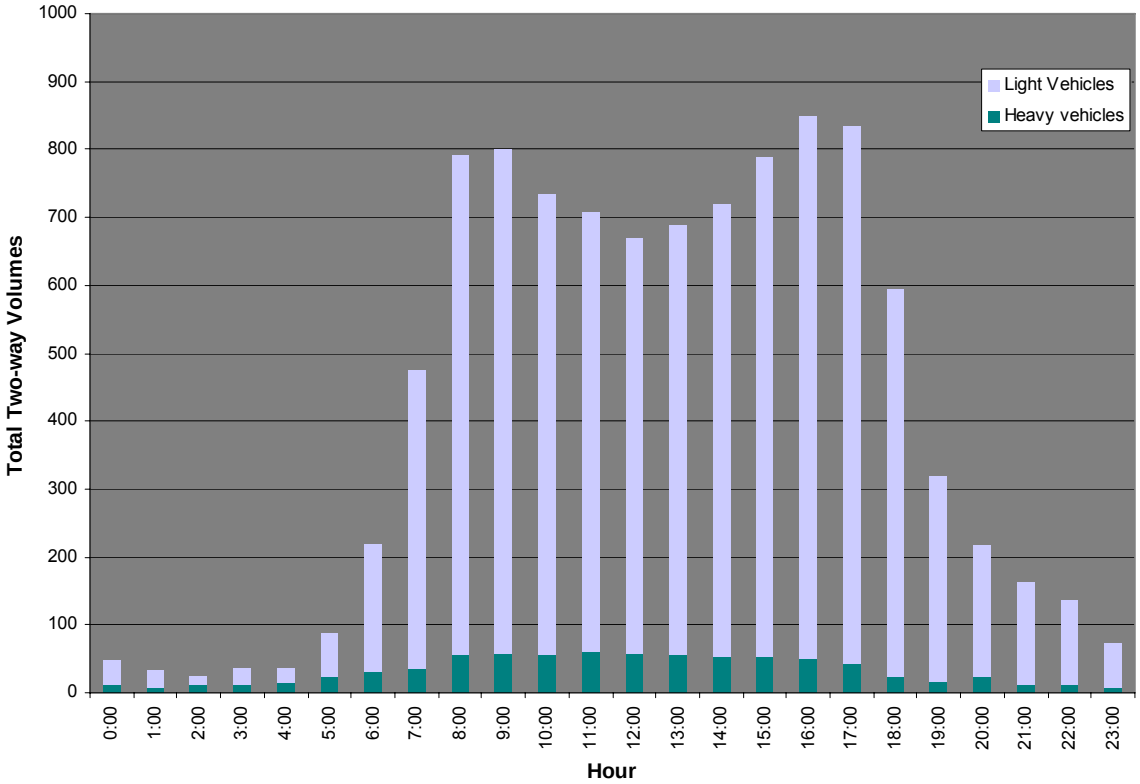


Figure 8.8 Local Access Arrangements for Preferred Route

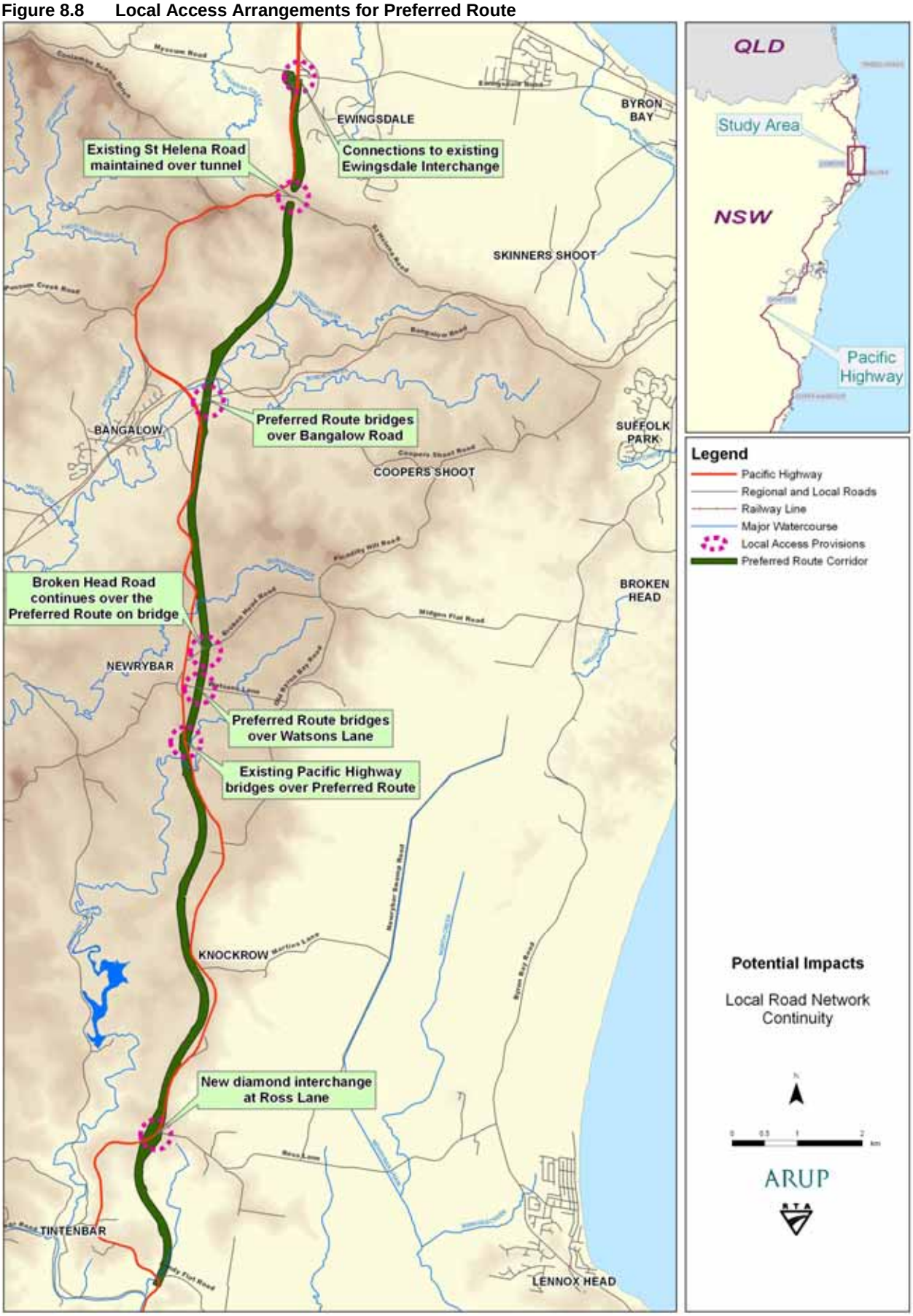


Figure 8.9 Local Traffic Volumes for Preferred Route

8.4 Geotechnical

The preferred route traverses soft soils near Sandy Flat, but generally avoids identified areas of geological instability along the plateau. Due to the large number of springs in the study area it was not possible for the preferred route to avoid all of them, but the design corridor has been modified to reduce impacts on springs and to avoid springs being affected by double sided cuts for which mitigation would be difficult.

The location of the preferred route in relation to the geology of the study area and the identified geotechnical features is provided in **Figure 8.10** and **Figure 8.11** respectively, and discussed below.

8.4.1 Impacts on Springs

Sections A1-a, B1-b and A2 of the preferred route may each impact a limited number of known springs. Further investigations aimed at identifying springs in the vicinity of the preferred route will be conducted as part of detailed concept design.

Engineering mitigation is expected to be feasible for situations where embankments and hillside cuts are to be constructed over the location of springs. Possible measures to mitigate the impact of the preferred route on springs and the groundwater regime are illustrated in **Figure 8.12**. Based on the current concept design, none of the potentially affected springs would be within a double sided cut.

The preferred tunnel alignment is expected to be located mostly within a medium to very high strength basalt layer resulting in low groundwater inflows and minimal impact on the groundwater regime.

8.4.2 Soft Soils

Data from the Ballina Bypass geotechnical investigations (Robert Carr and Associates, 2002) indicates that the preferred route over Sandy Flat floodplain is underlain by soft soils typically up to about 5 m depth. Close to the intersection with the existing Pacific Highway, soft soils are present to depths of up to 10 m. The presence of shallow soft soils may impact on construction costs and programs relating to fill embankments. Soft ground treatment (possibly surcharging, and staged construction) would be required to limit the impact of long-term settlements on pavement performance and maintain stability during construction. The experience of soft ground treatment gained on a larger scale for the Ballina Bypass (south of the study area) can be used to help mitigate any risks for construction on soft soils for this project.

8.4.3 Geotechnical Stability

The vertical alignment of the road as it climbs the escarpment between Sandy Flat and Ross Lane will need to be carefully designed so as to avoid cutting below the geological contact between the basalt and the underlying argillite. This does not appear to be a major difficulty based on the preliminary concept design profiles.

On the top of the plateau through to the end of Section B1-c, the preferred route traverses rolling hills with some incised gullies. Generally fills will be less than 10 m deep while maximum cut depths are in the range of 10 to 15 m with the exception of one 20 m deep cutting south of Emigrant Creek. Drill and blast would be unlikely for these cuts except for localised high strength layers. Fill materials made available from the cuttings would in most cases be suitable for use as general fill. Embankment construction in this area is expected to be relatively standard, with only minor geotechnical issues. The preferred route is far enough from the top of the escarpment to avoid impacts in areas of high hazard geotechnical instability (see **Figure 8.11**).

Section A2 would include a cut about 30 m deep within the upper slopes of the southern side of the broad valley occupied by Byron Creek. It is likely that significant thickness of relatively high strength basalt at shallow depth would be encountered in this cut. Drill and blast would be likely

with the opportunity to obtain select materials for construction. Further detailed investigation is required for the larger cuts north of Byron Creek, however major geotechnical impacts are unlikely.

The preferred route tunnel alignment is expected to be mainly within a basalt layer of medium to very high strength with relatively good tunnel support conditions. A tunnel through this rock type would likely need to be excavated by drill and blast. Excavation from the northern and southern portals would be expected to encounter variable geotechnical conditions, with interlayered low and high strength basalt, some of which would require excavation by drill and blast. There are some potential landslide hazards on the slopes north and south of the tunnel and these will need to be considered in the techniques used for construction.

Some fill earthworks would be required at the northern approach to the tunnel. These earthworks are expected to be within routine construction practice.

The preferred route includes a service road on the west side of the ridge traversed by the existing Pacific Highway, between the Ewingsdale interchange and St Helena Hill. Colluvium or landslide debris is present on the part of these slopes. The concept design has been refined so that embankments for the service road do not encroach over the colluvium.

Figure 8.10 Geology

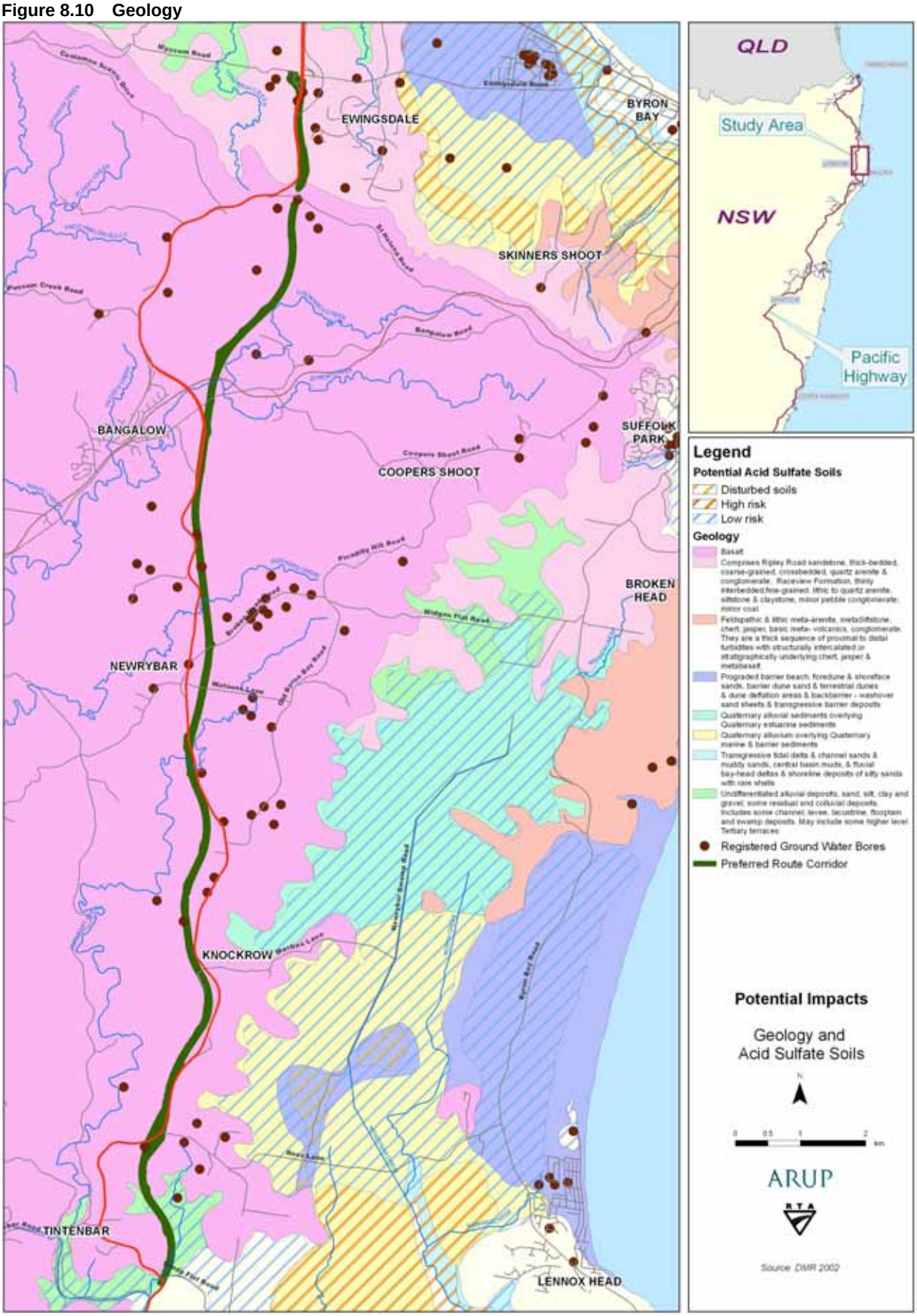


Figure 8.11 Geotechnical Features

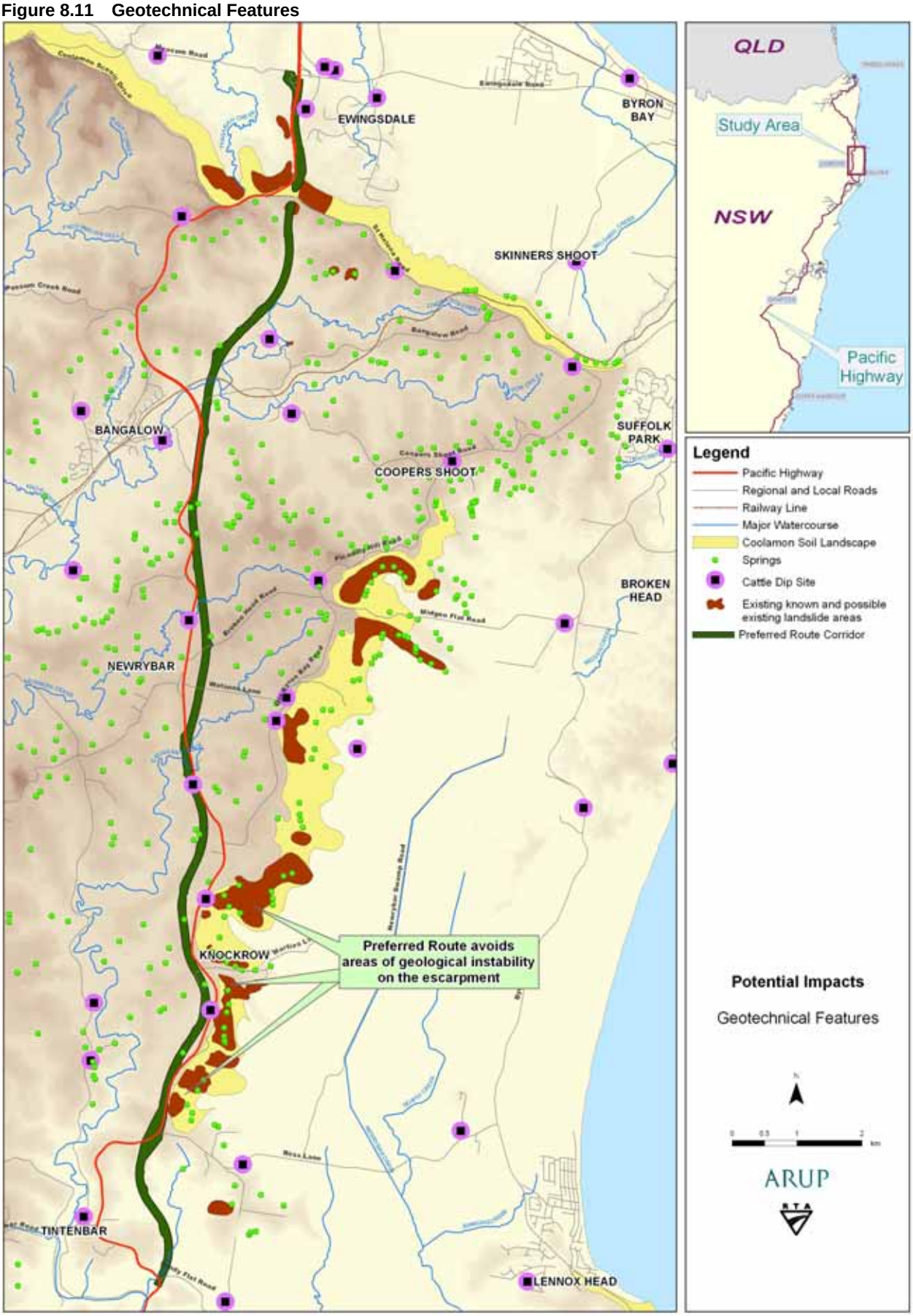
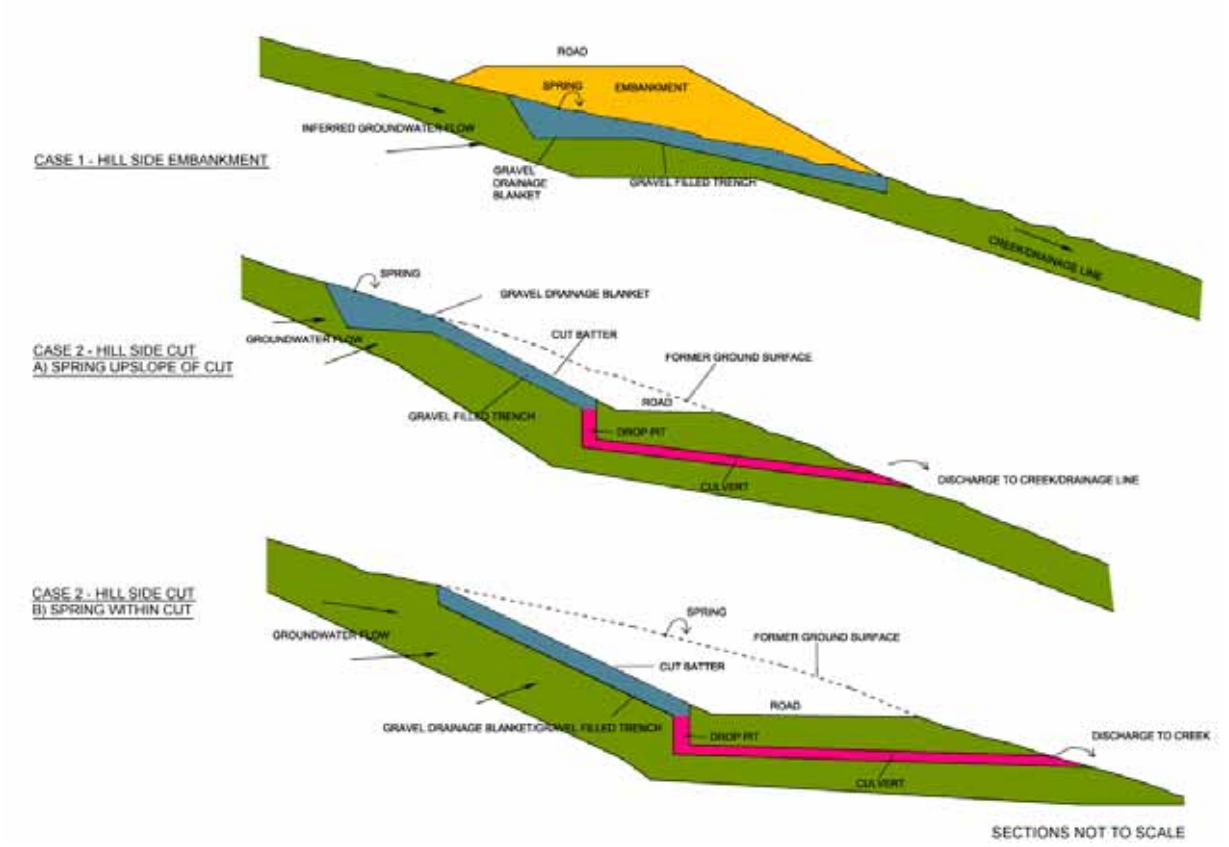


Figure 8.12 Mitigation of Impact on Springs



8.5 Hydrology and Flooding

The preferred route is generally located on the plateau and as such avoids the Newrybar Swamp floodplain where most flooding constraints were identified. The preferred route does, however, cross a number of watercourses on the plateau, including Emigrant Creek, Skinners Creek and Byron Creek. **Figure 8.13** shows the location of the preferred route in relation to flood zones and significant watercourses.

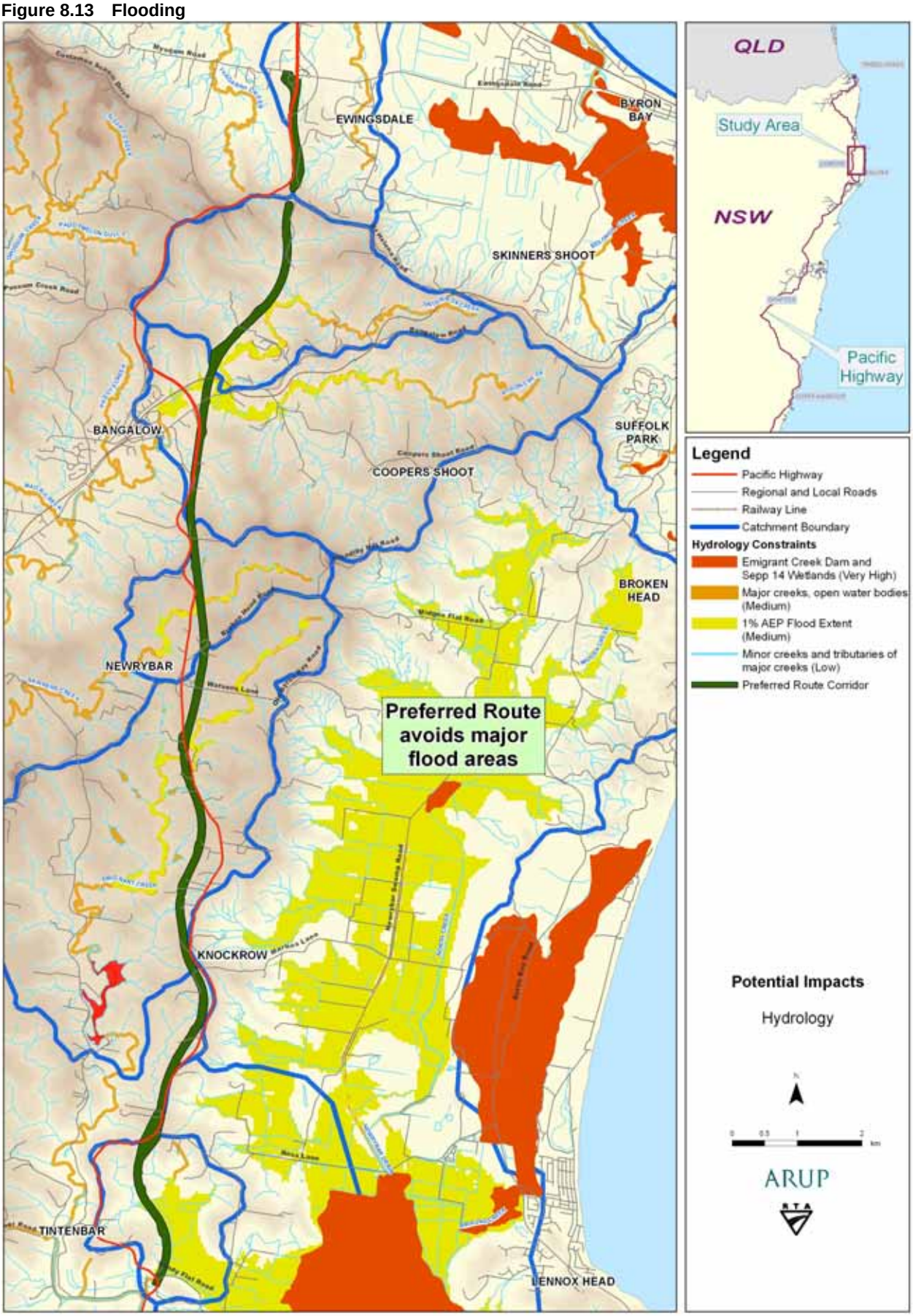
The preferred route is within 300 m of Emigrant Creek for approximately 1.25 km and best management practices would be utilised to reduce the risk of impacts on the creek during both construction and future operation of the highway.

North of Ross Lane, the preferred route crosses Emigrant Creek, Skinners Creek and Byron Creek. The 1% AEP event has been calculated for these creeks and appropriate structures provided in the concept design for this flow.

In addition to the issues discussed above, Sections A1-a, B1-b, and B1-c cross a number of minor creeks where hydraulic continuity would be provided by means of appropriately sized culverts and pipes. Further, as a result of cuttings in some sections of the highway, a limited area of the sub-catchments would require diversion to the next downstream waterway crossing the highway.

Further modelling will be required as part of the refinement of the concept design to ensure that standards required for the upstream afflux are achieved.

Figure 8.13 Flooding



8.6 Planning and Land Use

8.6.1 Statutory Land Use Planning

Neither the *Byron Local Environmental Plan 1988* nor the *Ballina Local Environmental Plan 1987* prohibits roads in any of the zones traversed by the preferred route. In addition, the preferred route would not require development consent through either application of the provisions of the LEPs or *SEPP 4 - Development Without Consent and Miscellaneous Exempt and Complying Development*. Notwithstanding this, it has been decided that assessment of the preferred route is required under the provisions of Part 3A of the *Environmental Planning and Assessment Act 1979*, and approval from the Minister for Planning would be required.

As part of this environmental assessment required under Part 3A of the *Environmental Planning and Assessment Act 1979* a full review of the relevant environmental planning instruments would be carried out.

8.6.2 Residential Land Use

The preferred route would directly impact a number of individual dwellings, as well as groupings of residences, and areas that have been identified for future residential or urban land uses. **Figure 8.14** shows the location of the preferred route in relation to these residential land use constraints, and a summary of these impacts are provided below. Individual dwellings that are directly affected by the preferred route are discussed in the **Section 8.7**.

In the southern part of the study area, the preferred route follows the general alignment of the approved Ballina Bypass. Along this part of the route there are no directly affected contiguous settlement areas. Further, while the route passes through a significant amount of land zoned under the Ballina LEP as an urban investigation zone, the route avoids any direct impacts to land identified within Ballina Council's Cumbalum Structure Plan.

Section A1-a would affect residences within two separate settlement areas, impacting on linkages between residents within the settlement areas. The first is located near the intersection of Ross Lane and the existing Pacific Highway, where there is a proposed interchange. The second settlement area is further to the north near Martins Lane West at Knockrow. In addition, 12.5 hectares of land zoned under the Ballina LEP as an urban investigation zone would be affected; however there would be no direct impact on land identified within Ballina Council's Cumbalum Structure Plan.

Section B1-b would sever a contiguous settlement in the area of the existing Pacific Highway around the Emigrant Creek crossing and Hambly Lane. This section avoids Macadamia Castle and the contiguous settlement that is located on the existing Pacific Highway near Macadamia Castle. The preferred route also affects residences in the small settlement on Ivy Lane.

Section B1-c would not directly affect any contiguous settlement areas. It also avoids Newrybar village, and passes to the east of Newrybar School avoiding segregation of the school from the village. However, this section would be close to the school, and would cause some perceived segregation between Broken Head Road settlements to the east and the village/school. Broken Head Road would remain linked to the village and the school via a bridge over the upgraded highway. The proximity of the preferred route to the school and subsequent location of the school between two major roads (old and new Pacific Highways) is an important issue. Ongoing consultation between the Project Team, the school, and the school community will focus on safe accessibility and the integrity of the school.

Section A2 would sever a contiguous settlement area immediately south of Bangalow (between Lawlers Lane and Bangalow), but avoids Bangalow, passing to the east of the town. It would not impact on any future planned residential development areas.

The contiguous settlement area along St Helena Road would not be impacted by the tunnel associated with Section T2. This section also passes to the west of Ewingsdale, avoiding any direct impacts on the settlement.

8.6.3 Agricultural Land Use Impacts

Since the RODR was publicly displayed, agricultural land use impacts have been considered in additional detail through discussions with affected landowners and the landowner survey that was undertaken. The comparative assessment of agricultural impacts (see **Chapter 3)** provided information that was used to reduce agricultural impacts in the refinement of the design corridor.

The comparative assessment of agricultural impacts is based on a methodology of estimating agricultural worth as described in detail the *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Working Paper on Agricultural Considerations for Route Options* (RTA 2006).

Table 8.4 summarises the impacts on agriculture associated with each of the sections of the preferred route. This assessment is generated from the estimate of the worth used for the comparative analysis of the route options (see **Chapter 6**) and will not be used to determine the value of individual properties in the acquisition phase of the project. **Figure 8.15** shows the location of the preferred route in relation to the agricultural land uses.

Figure 8.14 Very High and High Constraint Land Use Areas

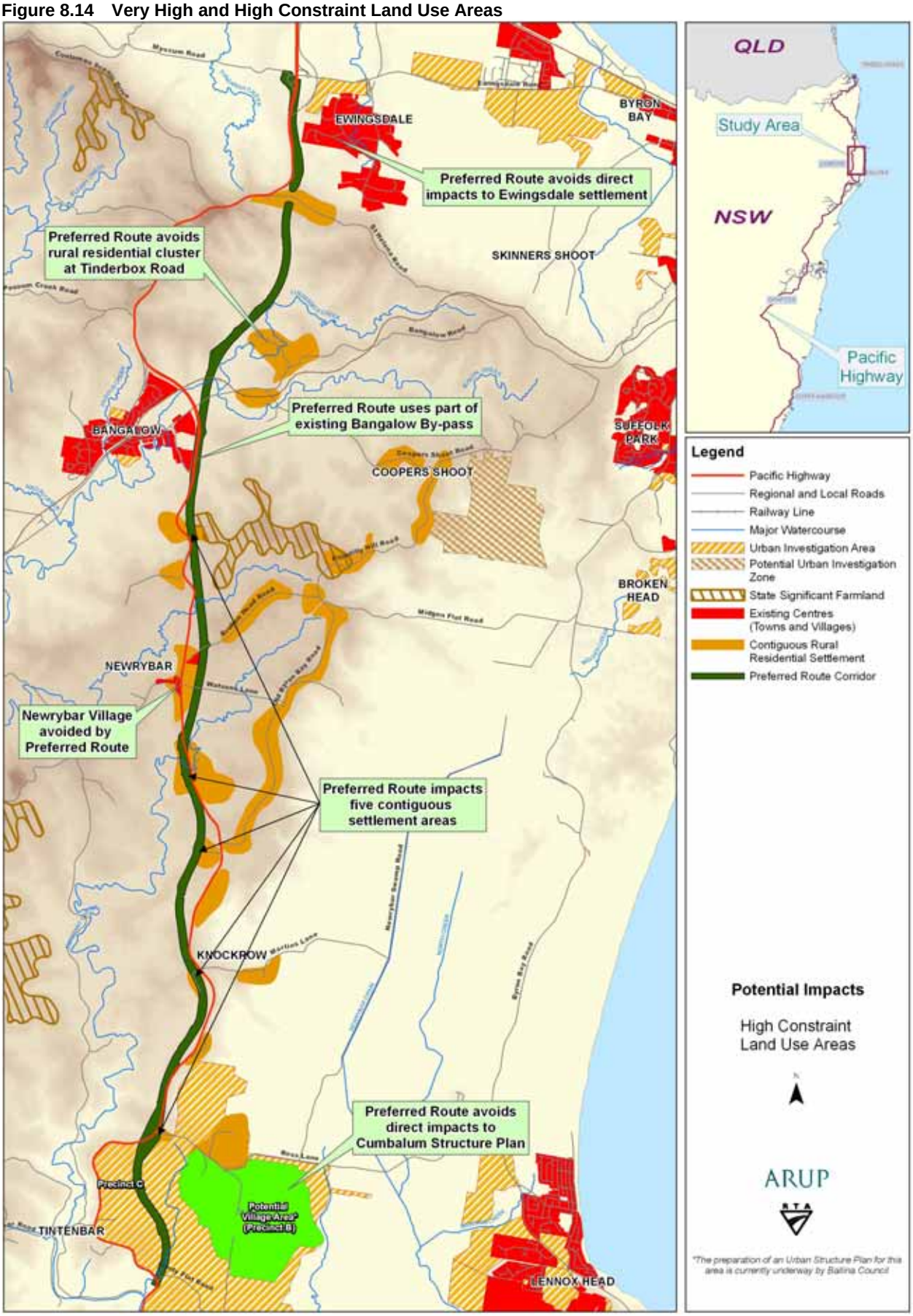


Table 8.4 Agricultural Impacts of the Preferred Route [1,2]

Section	A/B	A1a	B1b	B1c	A2	T2
Characteristics of Section						
Length (km)	1.4	3.8	3.6	3.0	5.2	2.5
Dominant land use	Grazing and timber	Grazing (plateau)	Mature macadamias and grazing (plateau)	Mature macadamias	Grazing (escarpment)	Grazing (escarpment)
Number of lots[2]	4	22	19	13	17	8
Number of landowners	4	19	19	11	15	6
Direct Impacts of Footprint for the Preferred Route[3]						
Area (ha)[4]	11	35	30	22	37	16
Major land uses	Grazing 100%	Grazing (plateau) 50%, timber 16%, grazing (escarpment) 16%, mature macadamias 9%	Grazing (plateau) 40%, mature macadamias 34%, nurseries 10%	Mature macadamias 30%, timber 23%, immature macadamias 18%	Grazing (escarpment) 82%, mature macadamias 7%, timber 6%	Grazing (escarpment) 80%, timber 16%, grazing (plateau) 4%
Impact on agriculture [5]	$0.19 M	$1.37 M	$1.81 M	$1.18 M	$0.83 M	$0.28 M
Indirect (severance) Impacts of Footprint for the Preferred Route						
Residual area of severed lots (ha)[6]	92	291	237	190	437	163
Major land uses	Grazing (escarpment) 91%, timber 9%	Grazing (plateau) 40%, grazing (escarpment) 22%, mature macadamias 16%, timber 12%	Mature macadamias 47%, grazing (plateau) 26%, other fruits 6%, nurseries 4%	Immature macadamias 27%, grazing (plateau) 25%, mature macadamias 13%	Grazing (escarpment) 57%, mature macadamias 15%, timber 11%	Grazing (escarpment) 63%, timber 19%, grazing (plateau) 16%
Affected area of agricultural land within severed lots (ha)[7]	6	67	73	33	33	8
Impact on Agriculture [8]	$0.01 M	$1.08 M	$1.23 M	$0.52 M	$0.37 M	$0.03 M

1 Details of the assumptions and methodology for calculating the impact on agriculture is provided in *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Working Paper on Agricultural Considerations for Route Options* (RTA 2006). The data in the table refer to impact on agricultural land only. It excludes all buildings, crown land, schools, rural residential lots (allotments <3ha).

2 Discrete parcel of land related to land title boundary – some properties consist of two or more lots.

3 See definition of footprint in Glossary of Terms.

4 Agricultural land only, excludes other land uses such as Crown land, schools and residential land.

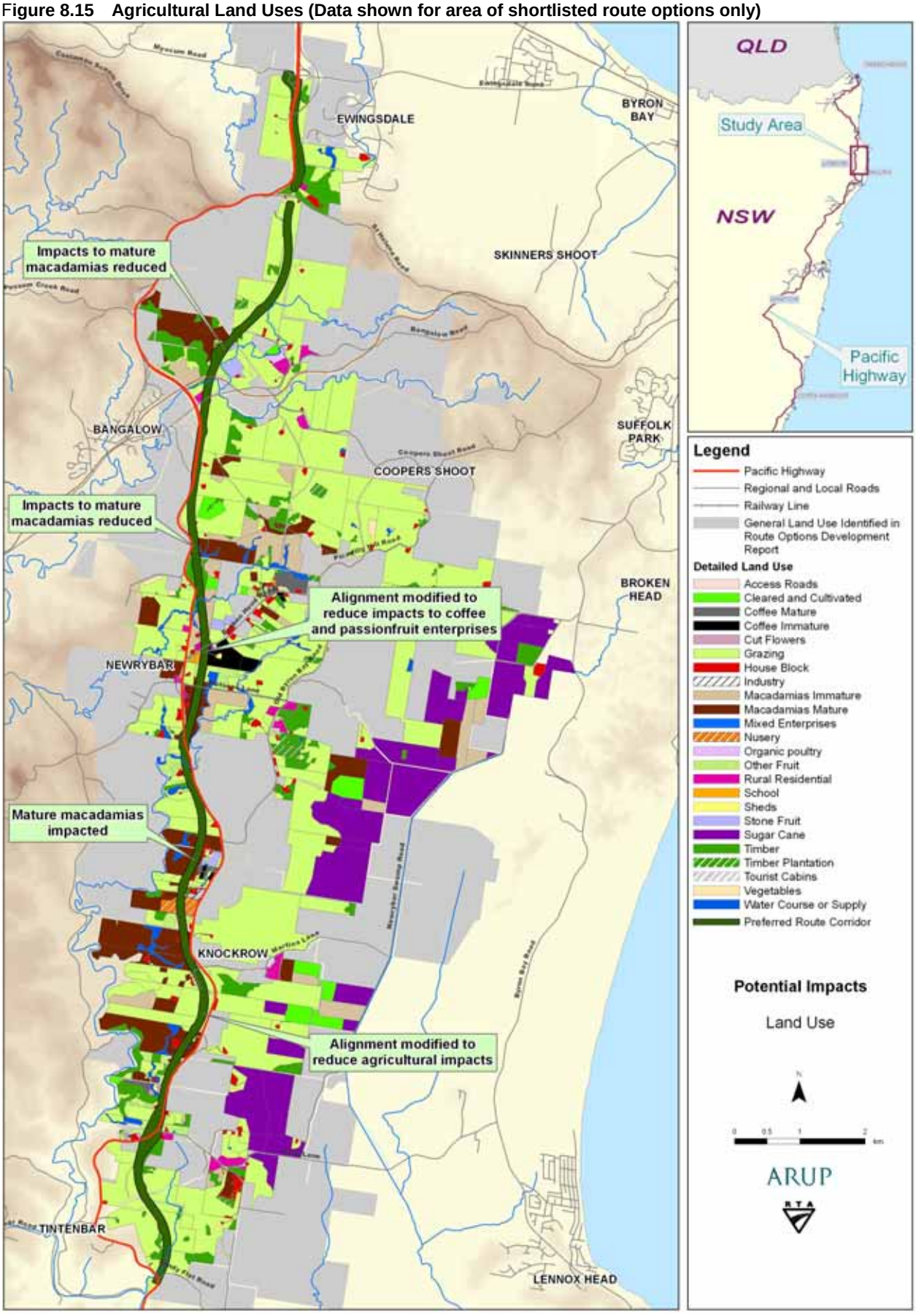
5 The impact is based on the land use, agricultural land worth linked to a market analysis, and agricultural improvement worth for the specific land use. The impact assessment was prepared to enable a comparison between the route options. It will not be used as the basis for determining the value of individual properties in the acquisition phase of the project.

6 The residual area is the remaining portion of a lot that is directly affected by the footprint of the route option.

7 That area within the severed lots that will be affected to varying degrees, depending on the land use and size.

8 The impact is based on the agricultural land worth linked to a market analysis and agricultural improvement worth for the land use each multiplied by the degree of affection applicable to location of land and enterprise. The calculations are described in *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Preliminary Assessment Report on Agricultural Considerations* (RTA 2006).

Figure 8.15 Agricultural Land Uses (Data shown for area of shortlisted route options only)



8.7 Socio-Economic

8.7.1 Impacts on Dwellings and Communities

Social impacts identified for the preferred route include:

- Dwellings directly affected.
- Lifestyle impacts associated with proximity to the highway (dwellings within 100 m of the preferred route).
- Severance impacts on communities and residential clusters.

In some areas the preferred route closely follows the existing Pacific Highway and would therefore directly impact on a relatively large number of residential dwellings as shown in **Table 8.5**. This table indicates the minimum number of residences for which acquisition and compensation would be required.

The number of dwellings that would be within 100 metres of the preferred route is also listed as an indication of the change to the amenity of surrounding properties, defined as lifestyle impacts (see Evaluation Criteria, **Appendix B)**.

As noted in land use considerations (see **Section 8.6**), the preferred route impacts areas of contiguous settlements. These are also considered social impacts due to severance of existing 'neighbourhoods' and corresponding impacts on individuals living in the areas.

Table 8.5 Social Impacts of the Preferred Route

Section	A/B	A1a	B1b	B1c	A2	T2	Total
Number of dwellings directly affected	0	15	6	1	3	0	25
Lifestyle impacts (number of dwellings within 100 m of the preferred route)	0	31	14	6	13	9	73

8.7.2 Economic Impacts

Market economies are complex and, by their very nature, adaptive systems. Changes in the availability of scarce resources (such as land) would prompt adjustments to existing patterns of resource use – albeit the efficiency of such an adjustment would ultimately be affected by enterprise level considerations as well as other factors. An assumption of efficient adjustment to the impacts of the highway upgrade on agricultural land availability suggests that higher value agricultural activities that are displaced by the highway upgrade would be re-established on land currently used for lower value activities (notably grazing). There is significant concern amongst many affected land holders that the availability of land for such adjustments is constrained.

The economic modelling undertaken calculates that the effect of the preferred route on the GRP for the Byron Bay and Ballina local government areas is a reduction of $1.43 million per annum. This is a relatively high impact compared with the other route options, driven largely by the impacts on land which has a high production value (e.g. flowers, fruit and other tree crops), but it is modest in the context of the total GRP for Byron and Ballina which is around $1.7 billion per annum. Further, there are significant areas of grazing land that may be suitable for re-establishment of displaced high value agricultural activities which could reduce the regional economic impacts by up to 90%.

It should be noted that the proposed highway upgrade and its impact on current agricultural activities is just one of many significant economic drivers of change, and the assessment has not taken into consideration any other changes in the regional economy.

With regards to local business impacts, the preferred route would be expected to affect businesses in Newrybar, Knockrow and Bangalow that rely heavily on passing highway traffic. However, the preferred route allows for the retention of the existing Pacific Highway; encouraging its use for tourism and recreational purposes. Accessibility for businesses currently located on the Pacific Highway would be expected to improve as through traffic moves to the upgraded highway.

Macadamia Castle (see **Figure 8.16**) and Coffee Nirvana would experience impacts associated with changes in operating amenity and the landscape in which they are located. Transfer and consolidation of business activities, which might occur in the medium to long term, could represent significant benefits for consolidated urban settlements, in particular Newrybar and Bangalow.

Figure 8.16 Macadamia Castle

8.8 Drinking Water Catchments

The preferred route passes through both Emigrant Creek drinking water catchment and the proposed Lismore Source drinking water catchment, as shown in **Figure 8.17**. In total the preferred route would have a length of 5.1 km through the Emigrant Creek catchment compared to 4.7 km for the existing Pacific Highway. The preferred route would have a total length of 7.4 km through the proposed Lismore Source catchment.

The preferred route is located within 40 m of Emigrant Creek for a north-south distance of approximately 90 m, before crossing Emigrant Creek to the west of the crossing made by the existing Pacific Highway.

The potential impacts to water quality within Emigrant Creek catchment could be successfully mitigated by inclusion of best practice mitigation and management measures, including:

- Structures (such as bridges and culverts) designed and constructed in a manner appropriate for the size and topography of the watercourse.
- Provision of sediment containment structures and other water quality control measures to collect and treat road runoff prior to discharge into the creek system.

Figure 8.18 shows an example of water management where runoff from a bridge is collected and treated prior to being discharged. Through the application of such measures, the preferred route could be expected to provide improved conditions relating to water quality in the Emigrant Creek catchment compared with the existing Pacific Highway.

As the preferred route passes through the Emigrant Creek catchment and crosses Emigrant Creek, the Project Team will consult with Rous Water to determine appropriate mitigation measures to reduce the risks to Emigrant Creek Dam and the Ballina water supply.

Figure 8.17 Aquatic Ecology and Water Quality

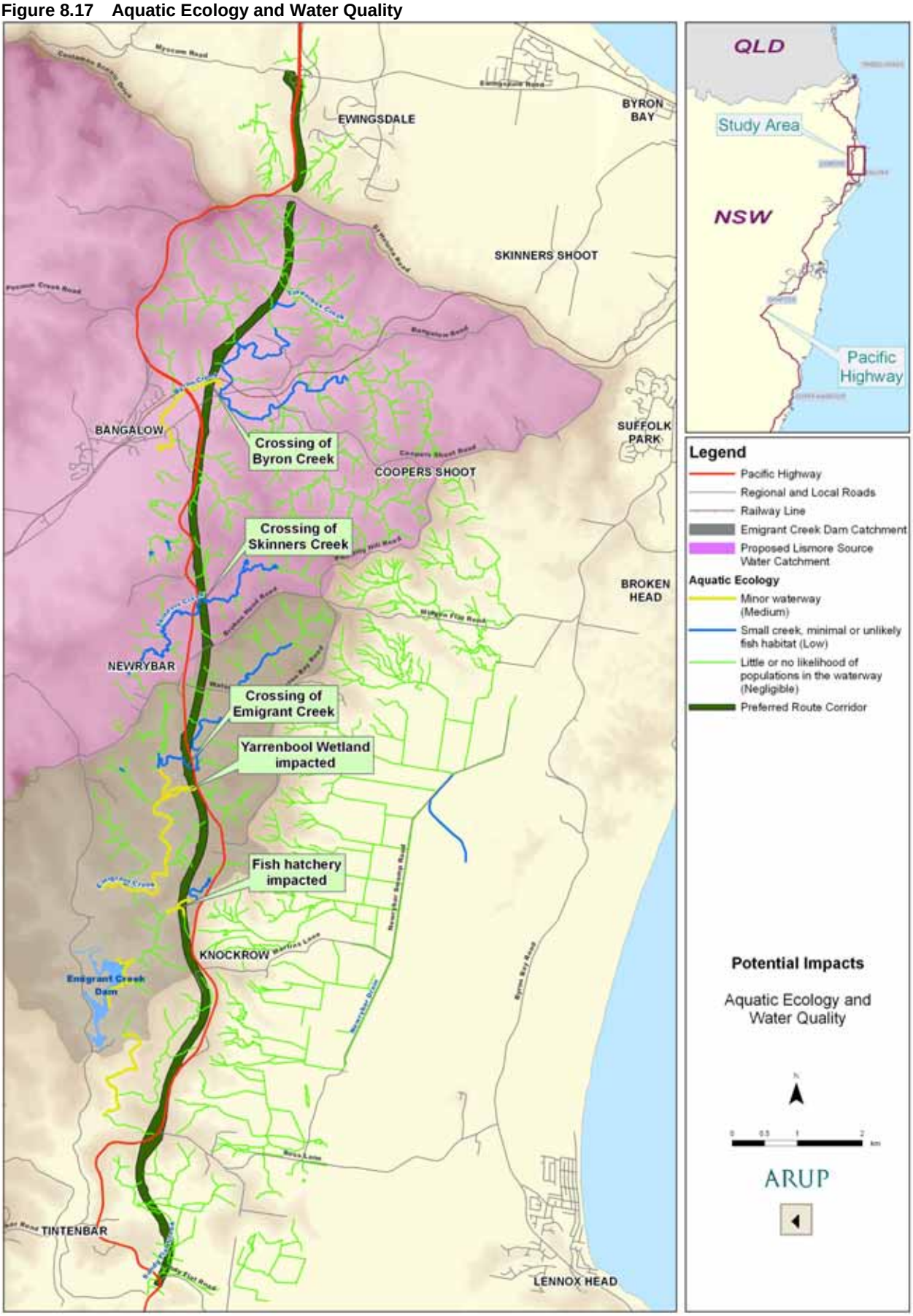


Figure 8.18 Waterway Mitigation*

* Bridge deck runoff is captured in the pipes via bridge scuppers and directed to sediment/wetland basin before being discharged into the watercourse.

8.9 Aquatic Ecology

The majority of waterways crossed by the preferred route are drainage lines or small tributaries of creeks that represent negligible ecological constraints (see **Figure 8.17**).

In addition to the crossings of small tributaries and drainage lines, the preferred route crosses Emigrant Creek, Skinners Creek, Byron Creek and Tinderbox Creek, or their tributaries, along stretches classified as low or medium constraints.

Figure 8.19 Fish Hatchery Pond

The preferred route crosses a minor tributary of Emigrant Creek at the location of the Palm Springs Fish Hatchery directly affecting several of the fish rearing ponds (see **Figure 8.17** and **Figure 8.19)**. This is an area of medium ecological constraints, however it would be possible for the fish hatchery ponds to be relocated.

The preferred route crosses the planted wetland at "Yarrenbool" (see **Figure 8.20**). The wetland is a medium ecological constraint, however only a small section would be impacted along its eastern edge that currently fronts the highway.

Figure 8.20 Yarrenbool Wetland

North of the Yarrenbool wetland the preferred route crosses Emigrant Creek, and north of Newrybar it crosses Skinners Creek.

Southeast of Bangalow, two existing crossings of tributaries of Byron Creek would be crossed by the preferred route. The preferred route would then deviate eastward from the Pacific Highway at Bangalow Road, crossing Byron Creek in a reach of the creek with medium ecological constraints, before making several crossings of tributaries of Tinderbox Creek.

Sufficient assessment has been carried out at this stage to recommend types of waterway crossings that would comply with agency guidelines for the protection of aquatic habitats. Where required, mitigation would be accomplished by implementing current best practice in road design and construction as discussed in **Section 8.8**.

8.10 Terrestrial Ecology

The location of the preferred route in relation to the terrestrial ecology constraints, including mapped and classified vegetation patches and wildlife corridors, is shown in **Figure 8.21**, and discussed in the following sections. While the figure also indicates the approximate location of threatened species that have been previously recorded, it is noted that at present no targeted searches for threatened species have been carried out.

8.10.1 Habitat Impacted

The impacts on high constraint vegetation, including EECs, are summarised in **Table 8.6**. The preferred route would have an impact on ten patches of the preliminary-listed EEC Lowland Rainforest, which contains habitat for threatened plant and animal species. In some cases threatened species have been previously recorded in these patches, whereas in others there are recordings of threatened species outside of the EEC patches. While all high constraint vegetation patches may contain threatened species, the following threatened flora species have been previously recorded within the boundaries of the preferred route footprint:

- *Tinospora tinosporoides* would be directly affected by Section A/B.
- *Syzygium moorei*, *Diploglottis campbellii* and *Macadamia tetraphyll* would be directly affected, but are outside of the classified vegetation patches and have been planted by the property owner (Section A1-a).
- *Syzygium moorei* would be directly affected by Sections B1-b and A2. The entire patch on Section B1-b has been planted by the property owner.

No threatened animal species have been previously located within the boundaries of the preferred route footprint or within vegetation patches directly affected by the preferred route. However it is likely that threatened animal species utilise vegetation patches directly affected by the preferred route. The following threatened animal species have been previously recorded in close proximity to the preferred route: Rose-crowned Fruit-dove, Black-necked Stork and Koala.

Sections A/B, B1-c, A2 and T2 would also directly affect patches of low constraint Camphor Laurel. These patches provide potential habitat for threatened plant and animal species although none have been previously recorded within these patches.

Table 8.6 Impacts of the Preferred Route on High Constraint Vegetation

Section	A/B	A1a	B1b	B1c	A2	T2	Total
Number of patches of high constraint vegetation affected	2	2	1	0	4	1	10
Area of high constraint vegetation affected (ha)	0.3	0.6	0.5	0	1.7	0.2	3.3

8.10.2 Platypus

It is considered unlikely that the platypus or its habitat would be significantly affected by the preferred route. Waterways that would be crossed are generally small and would be crossed, where feasible, with a single span bridge, thus causing minimal disturbance to the waterway and its riparian zone. Where single span bridges would not be practicable, piers would be located clear of waterways.

8.10.3 Wildlife Corridors

As shown in **Figure 8.21**, the preferred route would cross two wildlife corridors identified by the DEC, one at the southern end of the study area near Sandy Flat Road and the other where the tunnel passes underneath St Helena Hill. The vegetation within these corridors has been fragmented by cleared farm land and the existing Pacific Highway, and the corridors are not considered to be functional.

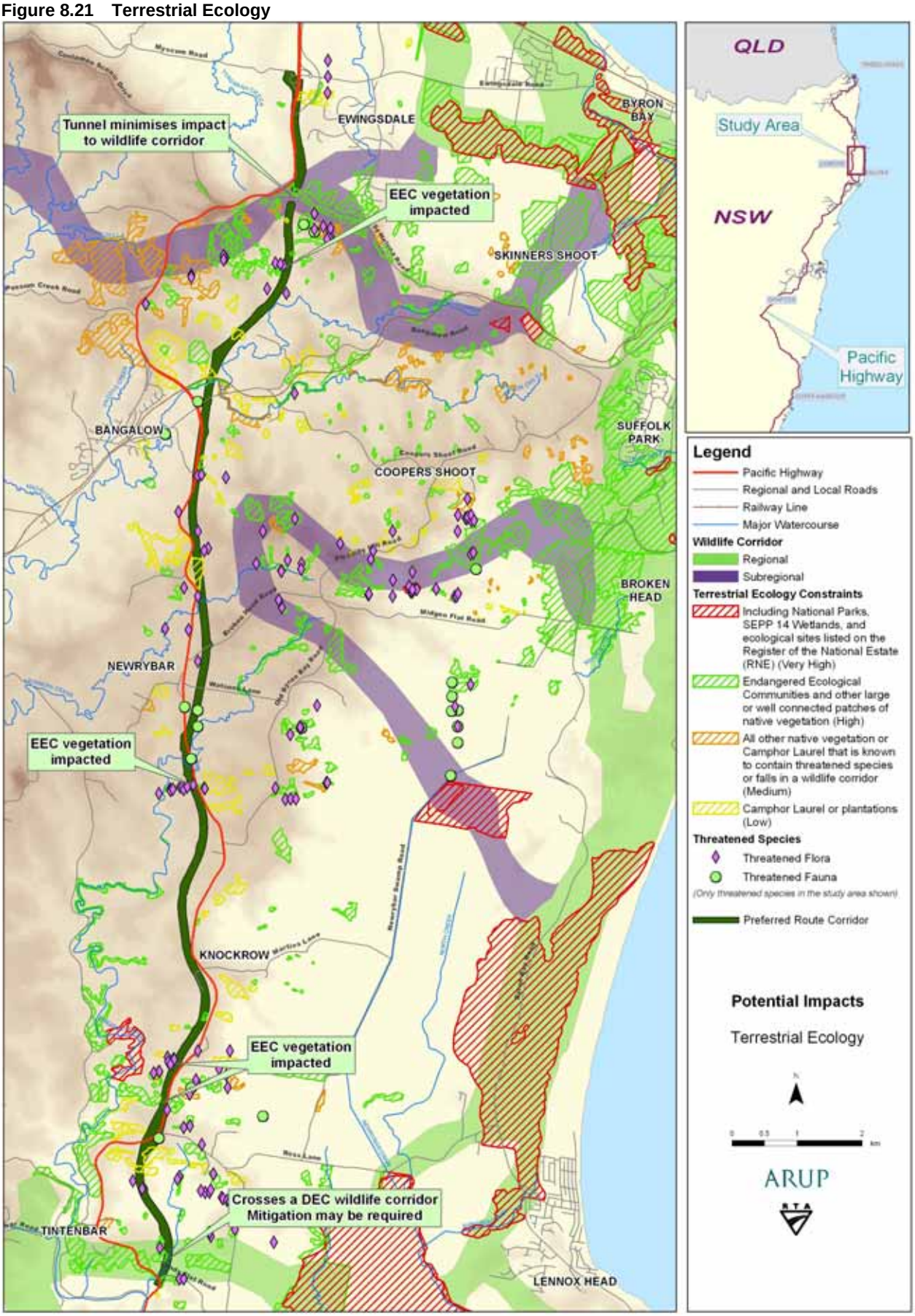
It is understood that the Councils and the local land owners may revegetate these corridors, meaning that mitigation measures would need to be considered to allow fauna movements across the preferred route. Close collaboration with Ballina and Byron Shire Councils will be maintained during the concept design stage of the project.

The tunnel, Section T2, passes underneath most of the corridor and would not disrupt connectivity along the corridor.

Appropriate mitigation measures for the construction and operation phase of the preferred route would be identified as the design, planning and environmental assessment of the project progresses. Mitigation measures that could be considered include fauna crossing structures, sediment and erosion control measures during construction and operation phases, revegetation and rehabilitation using locally endemic species and a weed management plan.

Where the preferred route would result in direct impacts on threatened species or potential habitat for the threatened species, detailed assessment pursuant to Section 5A of the EP&A Act would be undertaken as part of the detailed environmental assessment for the project.

Figure 8.21 Terrestrial Ecology



8.11 Cultural Heritage

The preferred route would not directly affect any known Aboriginal heritage sites, but could potentially affect four non-Aboriginal heritage sites. The location of the preferred route in relation to cultural heritage constraints is shown in **Figure 8.22** and **Figure 8.23**. The key issues associated with Aboriginal and non-Aboriginal heritage for the preferred route are discussed below.

8.11.1 Aboriginal Heritage

While the preferred route would not directly affect any known Aboriginal heritage sites, it does have the potential to affect as yet unrecorded sites. Section A/B crosses two areas of basal slopes with high potential for Aboriginal sites, and Section A1-a crosses a spur with moderate to high potential. Section B1-b crosses four spurs with moderate to high potential for sites, and Section A2 crosses or touches on six spur lines with moderate to high potential.

The identification of the precise nature of the Aboriginal archaeological potential is dependant upon further investigations to identify the location of any unrecorded surface sites and the archaeological potential of spur crests and other areas identified as having archaeological potential. Subsurface testing might also be required, involving test excavations to determine the presence, extent, nature and significance of subsurface sites. Further work will be carried out in conjunction with the local Aboriginal community and consultation is ongoing.

8.11.2 Non-Aboriginal Heritage

The preferred route would potentially directly affect four European heritage sites (three farmhouses and a former cricket pitch). These sites are features of local significance rated as low constraints. The four sites are (from south to north):

- H23 - A slightly later (1920's) building would be affected by the preferred route. The site is not unique, nor is it in pristine condition, and its loss would have only a slight impact on the nature of the historic settlement pattern along the existing highway.
- H21 - A house that is approximately 100 years old and typical of many within the study area and surrounding district would be affected. The site contains another similar house that is in better condition in terms of integrity and heritage value and which would not be directly affected by the preferred route. The loss of this site would not compromise the cultural landscape.
- H9 - The cricket ground has been modified by plantations and although cricket can be still be played on the pitch, the original atmosphere and extent of the ground has been compromised. The loss of this site would be a loss to the history of the town of Newrybar, but the affect of the current highway and the modifications to the cricket ground have already affected the association of the site with the town.
- H13 - A circa 1930s house and associated fig trees, identified as having moderate local significance would be affected. The site includes a complex of farm buildings, which represent a typical class of dairying farmsteads common within the study area; however past modification to the house has reduced its heritage value. The loss of this complex would have an impact on the landscape history, but it would not remove the character of this industry from the region.

Where an impact on an item of non-Aboriginal heritage is unavoidable, archival recording of those places, including mapping and a detailed photographic record of the structures might be required concentrating on the original structures and siting within the landscape. Where appropriate, salvage excavation would also be considered.

Figure 8.22 Aboriginal Heritage

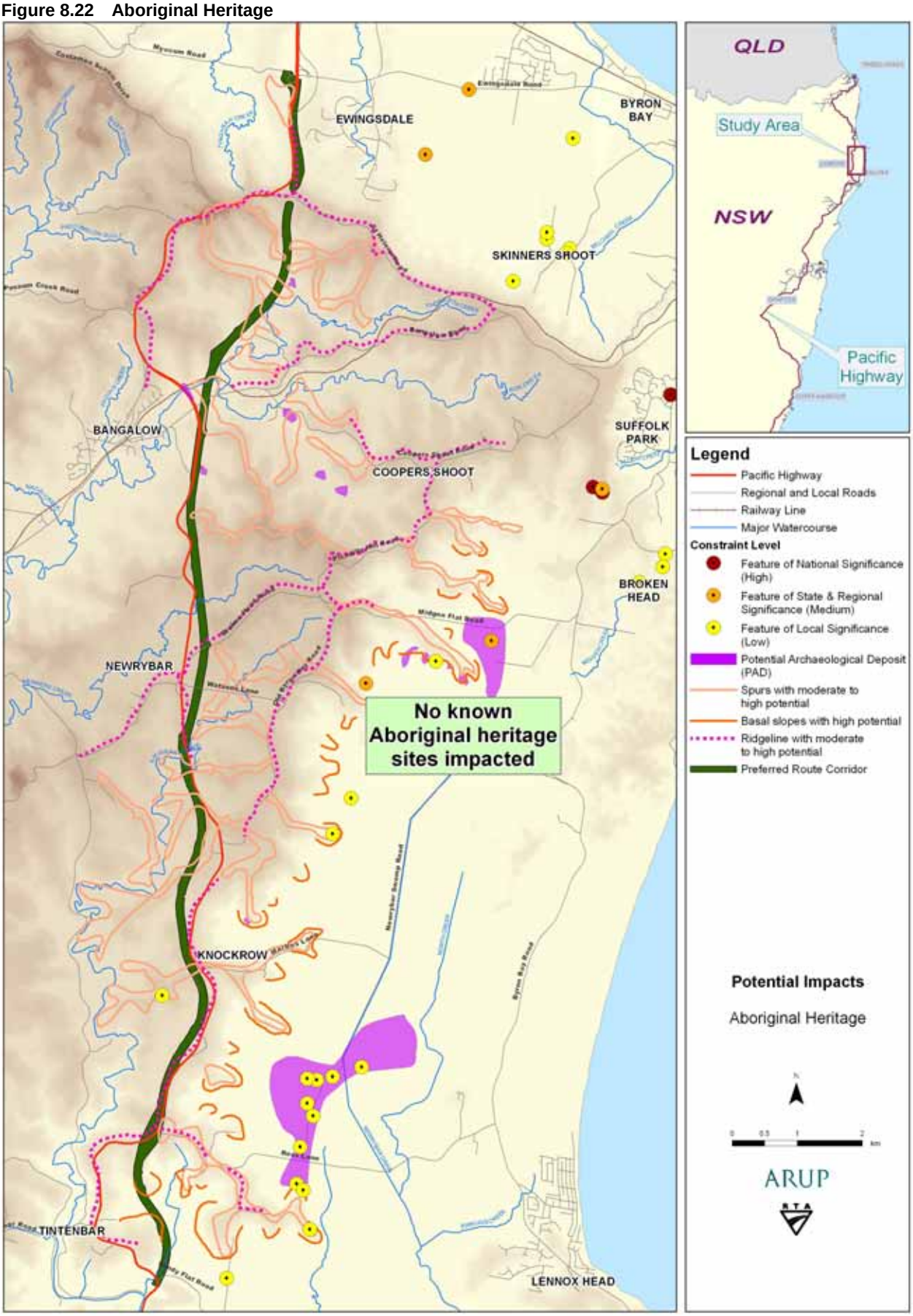
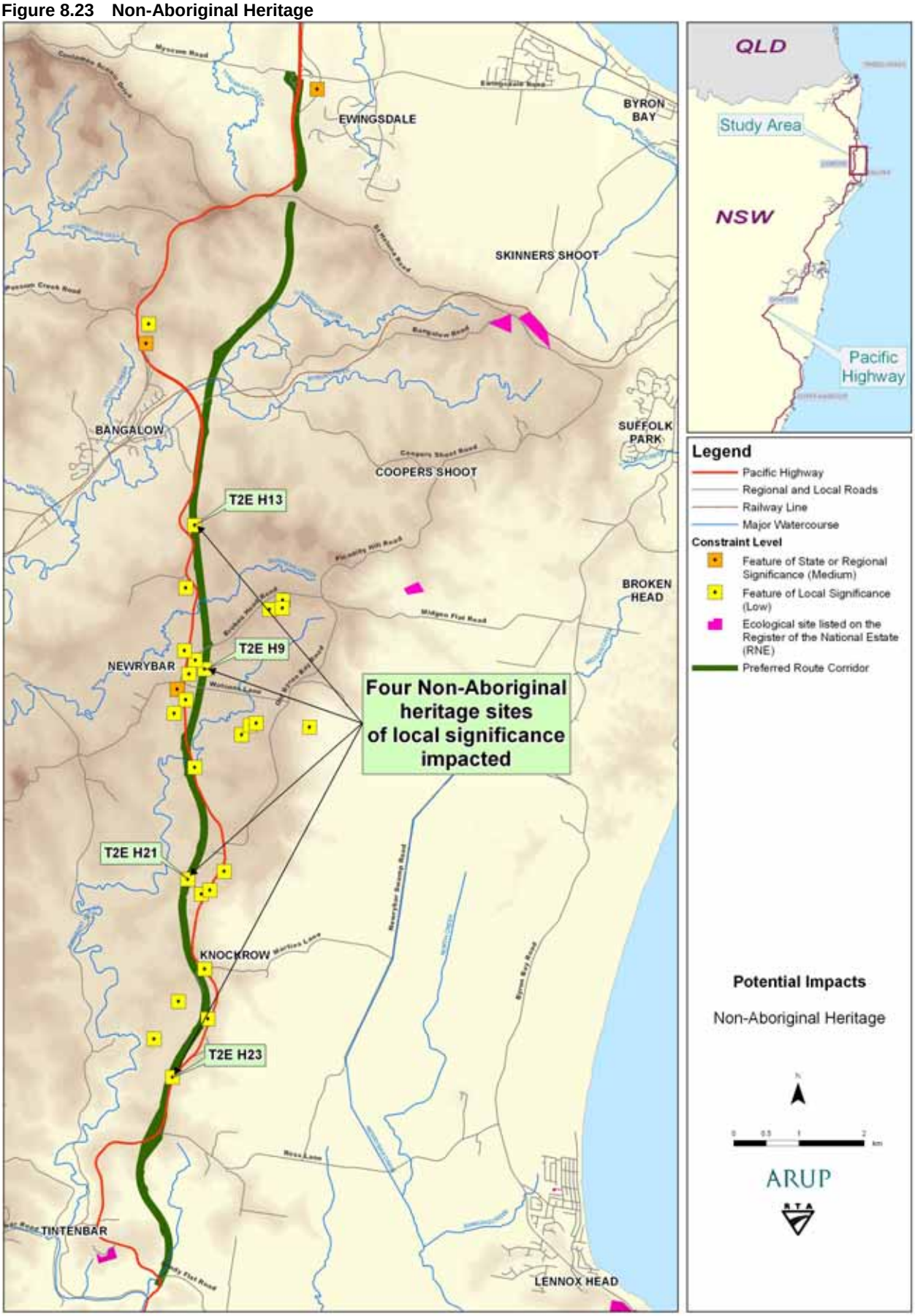


Figure 8.23 Non-Aboriginal Heritage



8.12 Landscape and Visual

This section describes the scenic quality of the landscape through which the preferred route passes, the visual exposure of the preferred route, the sensitivity of viewers to changes in that landscape, and the likely scale and extent of new road infrastructure.

8.12.1 Scenic Quality of the Landscape

Due to the proximity of the preferred route to the current highway, it would pass through similar landscape types as the existing highway for most of its length. The majority of the route would be located on the elevated and undulating plateau, which is largely characterised by agricultural plantations. These provide strong patterning to the landscape and provide a highly scenic, interesting and varied driving experience. Sections of the elevated plateau feature pastures or other more open landscape types which add to the variety and allow for more distant views into the surrounding countryside. Views are generally contained by the prominent ridgelines found on the plateau. The exception to this is formed by the southern-most and northern-most sections of the preferred route.

At its southern end, the preferred route traverses Sandy Flat Creek Valley, prior to climbing the escarpment edge to reach the elevated plateau near Ross Lane. A similar valley landscape is not traversed by the current highway and this would provide a new visual experience along the preferred route. The character of this landscape type is of medium scenic value compared to other landscape types and, as a result of the enclosed nature of the valley and the low number of potential viewers in this part of the study site, the visual impact of the route on this landscape type would be relatively low.

At the northern end of the preferred route, another new experience would be provided in the form of the tunnel through the St Helena Ridge, beyond which the route would be similar to the existing highway in the way it descends the long spur off the escarpment just west of Ewingsdale. The preferred route alignment and associated infrastructure such as the tunnel, its portal and associated cuttings on the approaches are likely to have a noticeable visual impact on the visual character on the escarpment edge at the St Helena Ridge.

8.12.2 Visual Exposure of the Route & Sensitivity of Viewers

Much of the preferred route follows the lower slopes and valley floors of the elevated plateau which will help to reduce its prominence in the area as many sections will be visible by only a limited number of people. The exception to this is where the preferred route is aligned immediately alongside the existing highway. In these areas the preferred route would be visible by large numbers of people, including residents along the existing highway and locals and visitors travelling along it. In the case of the section north of the St Helena Ridge, the route would be exposed to a potentially large number of highly sensitive viewers which include residents in Ewingsdale, users of the existing highway alignment and people at the McLeods Shoot Lookout.

Other areas with high numbers of viewers who may be sensitive to changes in the landscape include Macadamia Castle, the township of Newrybar and outlying residences, concentrations of rural residential properties such as along Broken Head Road, and the Newrybar School which attracts large numbers of people on a daily basis. Residents of Bangalow would also be highly sensitive to changes in the immediate visual environment, however, the area where the preferred route joins the Bangalow Bypass is already characterised by the presence of the bypass infrastructure, and this would be expected to reduce both the visual sensitivity of potential viewers to further changes and the visual effect of the preferred route. In addition, the area is visually quite well concealed from the township and would not increase the exposure of the town's residents to a major highway.

In contrast, viewers to the northeast of Bangalow would be sensitive to the significant deviation of the preferred route from the existing highway north of Bangalow, which would run through areas that are currently dominated by agricultural uses.

8.12.3 Scale and Extent of New Infrastructure

South of Bangalow, the preferred route remains relatively close to the existing highway alignment; north of Bangalow it deviates significantly from the existing highway avoiding St Helena Hill. Most of the existing highway would be able to be retained as a local and tourist route reducing the need for significant additional road infrastructure to maintain access to local settlements and properties.

Parts of the preferred route would require large or noticeable cuttings and embankments. The deepest cuttings would be located at the tunnel approaches on either side of the St Helena Ridge, and through tall ridge lines north and south of the existing Bangalow interchange and Tinderbox Road. **Figure 8.24** shows an artist's impression of the preferred route in the vicinity of Bangalow (looking north), showing the scale of the infrastructure likely to be required for the highway upgrade.

Figure 8.24 Artists Impression of Preferred Route near Bangalow (looking north)

8.13 Noise and Vibration

Noise modelling indicates that the preferred route would generally result in reduced noise impacts compared to the existing Pacific Highway alignment, as the preferred route is located further away from sensitive residences - many of which are in close proximity to the existing highway. The preferred route would comply with the intent of DEC's concerns regarding impacts on new receivers.

The preferred route results in unmitigated noise impacts higher than some of the other options; however noise mitigation would be possible, where required under the ECRTN. Potential mitigation could include low-noise road surfacing, noise barriers, and architectural treatments. These treatments offer the possibility of reducing the noise impacts.

The Absolute CNB, Relative CNB, and the number of properties above the target noise level for the preferred route are shown graphically in **Figure 8.25, Figure 8.26** and **Figure 8.27** respectively.

Figure 8.25 Absolute Community Noise Burden, Preferred Route

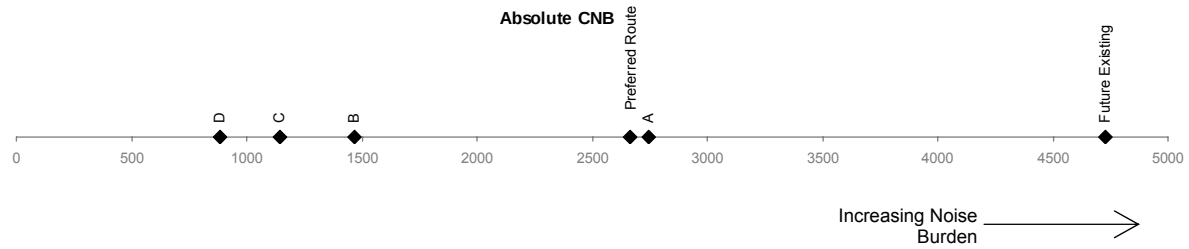


Figure 8.26 Relative Community Noise Burden, Preferred Route

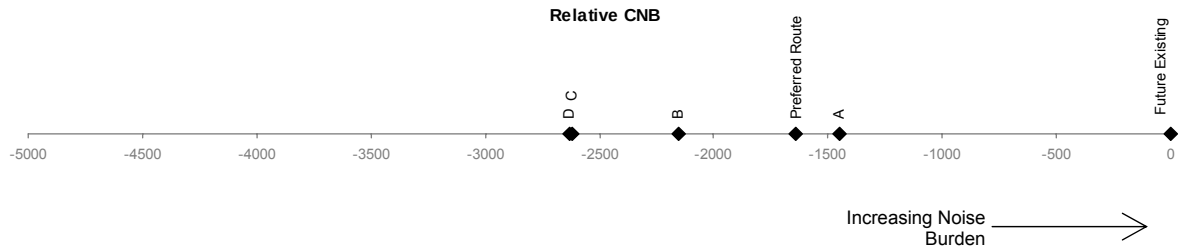
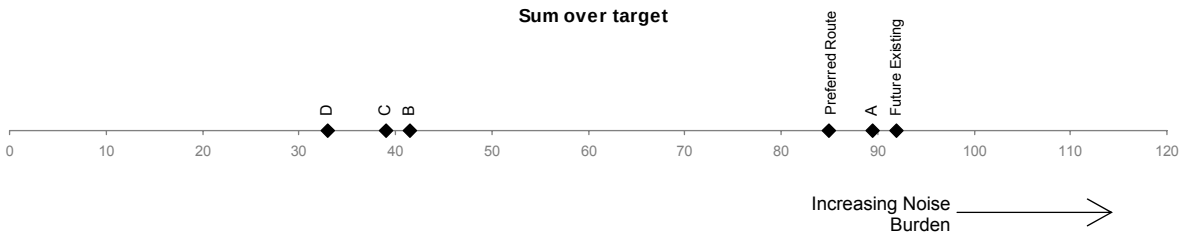


Figure 8.27 Number of properties above target noise level of 55 dBLAeq,15hr (Daytime, New Road)



A detailed acoustic assessment of the preferred route will be undertaken during the detailed environmental assessment for the project. This would involve detailed computer predictions of the noise impact of the preferred route alignment and assessment of noise mitigation in accordance with the RTA's guidelines. At this stage, it is expected that low noise road surfacing and/or noise barriers would be required in some areas of concentrated dwellings, for example, Ewingsdale, Newrybar, and Bangalow. Elsewhere, individual properties directly adjacent to the route are likely to qualify for architectural treatments (for example, upgraded windows, improved doors and seals and air-conditioning) to mitigate traffic noise break-in.

The requirement for and most applicable type of noise mitigation measures will be determined as part of the detailed environmental assessment.

As noted in **Section 3.10.7**, blasting is likely to be necessary for the construction of the tunnel. Blasting activities would be controlled to meet the ANZECC guidelines.

8.14 Air Quality

8.14.1 Greenhouse Gas Emissions

Detailed air quality assessments have not been conducted for this stage of the project. However, the change in greenhouse gas emissions can be estimated by calculating the reduction of CO_2 emissions associated with reduced travel times and increased travel efficiencies for the preferred route. The reduction in CO_2 emissions, compared with the do nothing option, was estimated for each of the shortlisted options using predicted traffic for a thirty year period starting in 2012. For the preferred route, the CO_2 savings would be approximately 16,800 tonnes per annum (averaged over the thirty year period).

Detailed air quality analysis will be undertaken for the preferred route as part of the environmental assessment for the highway upgrade. This analysis would be based on the results of dispersion modelling for pollutants from traffic on the highway including CO, NO_x and PM_{10} and takes into account predicted emission rates from vehicles on the upgraded highway, worst case meteorological conditions and the location of receptors.

The impacts would be assessed near the highway, at residences, schools and other sensitive locations where people spend a significant amount of time. The model would predict the increase in the concentration of pollutants from the roadway at each sensitive receptor, and with consideration of existing background pollution, compare this against the air quality criteria set out by the DEC. The purpose of the air quality assessment would be to determine the impacts of vehicle emissions on human health.

Dust, the principal construction air pollutant, would be generated from earthworks during construction of the proposed upgrade. An Air Quality Management Plan for the proposed works would be prepared and implemented during the construction phase, based on the DEC's recommended mitigation measures.

8.15 Summary of Preferred Route Characteristics and Impacts

A summary of the likely impacts associated with the preferred route is provided in **Table 8.7**. It is a compilation of data provided in the preceding sections in this chapter.

A summary of the key characteristics of the preferred route is provided in **Figure 8.28.**

Table 8.7 Summary of Likely Impacts of the Preferred Route

	Preferred Route Option Sections						Preferred Route[1]
	A/B	A1-a	B1-b	B1-c	A2	T2	
Engineering Characteristics							
Length (m)	1,400	3,800	3,600	3,000	5,200	2,500	19,500
Approximate length of tunnel (m)	0	0	0	0	0	250	250
Length of major bridges - highway (m)	10	0	210	120	210	0	550
Length of grades exceeding 4.5% (m)	120	1,210	0	0	1,400	0	2,730
Comparative travel time for heavy vehicles (minutes)	0.9	2.8	2.4	2.0	3.4	2.1	13.4
Number of horizontal curves with radius less than desirable (750m-1200m)	1	2	0	0	0	0	3
Length (m) of route that utilises existing road reserve (including 9(a) Zoning)	0	860	0	850	2,040	1,220	4,970
Length (km) through potentially fog prone areas.	1,440	330	400	650	3,310	1,380	7,500
Indicative cost ($M)	-	-	-	-	-	-	$368
Socio-Economic Characteristics							
Residential Areas							
Number of directly affected dwellings	0	15	6	1	3	0	25
Number of directly affected dwellings that are not within 200 m of existing Pacific Highway	0	1	3	1	1	0	6
Number of directly affected settlement areas	0	2	2	0	1	0	5
Agriculture and Land Use							
Area Directly Affected (ha) [2]	11	35	30	22	37	16	151
Direct Impact on Agriculture ($M)[3]	$0.19	$1.37	$1.81	$1.18	$0.83	$0.28	$5.66
Area of Residual Agricultural Land on Directly Affected Lots (ha) [4,5]	92	291	237	190	437	163	1,410
Indirect Impact on Agriculture (Severance) ($M) [3,5]	$0.01	$1.08	$1.23	$0.52	$0.37	$0.03	$3.24
Lifestyle							
Number of dwellings within 100 m of the outer edge of the footprint	0	31	14	6	13	9	73
Noise							
Absolute CNB [6]	30	230	310	320	1,330	450	2,650
Relative CNB [7]	-50	-350	-380	-310	-480	-80	-1,650
Length of Grades Greater than 3%	100	1,800	900	0	2,350	2,400	7,600
Number of dwellings where noise levels would exceed 55 dBA	1	8	5	8	45	18	85
Environmental Characteristics							
Terrestrial Ecology							
Number of Endangered Ecological Community and other high value vegetation or habitat patches directly affected	2	2	1	0	4	1	10
Approximate area of high constraint vegetation crossed (ha)	0.3	0.6	0.5	0	1.7	0.2	3.3
Number of 'edges' created through remnant and regenerated habitat areas	0	0	0	0	0	0	0
Number of times a regional wildlife a corridor is crossed	1	0	0	0	0	0	1
Aquatic Ecology							
Medium Constraint Waterways Crossed	0	0	3	0	1	0	4
Low Constraint Waterways Crossed	0	0	1	1	1	0	3
Drinking Water Catchments							
Length through Emigrant Creek Dam Catchment	0	50	3,600	1,450	0	0	5,100
Length through Proposed Lismore Source Water Catchment	0	0	0	1,500	5,200	650	7,400
Cultural Heritage							
Number of non-indigenous sites of local significance directly affected	0	1	1	1	1	0	4
Air Quality							
Quantity of CO_2 emissions savings (tonnes per annum)	1,300	3,250	3,000	2,600	4,400	2,250	16,800

Notes:

1. Due to rounding of numbers, preferred route totals may not equal sum of the sections.

2. All directly affected land, including non-agricultural lands, but excluding Crown Land.

3. While agricultural impacts include impacts on sheds, they do not include impacts on residential dwellings on agricultural properties or rural residential properties. Where the agricultural impacts for two sections of the preferred route fall on the same property (i.e. where the sections connect with each other) the worth of the impact has been divided equally between the sections.

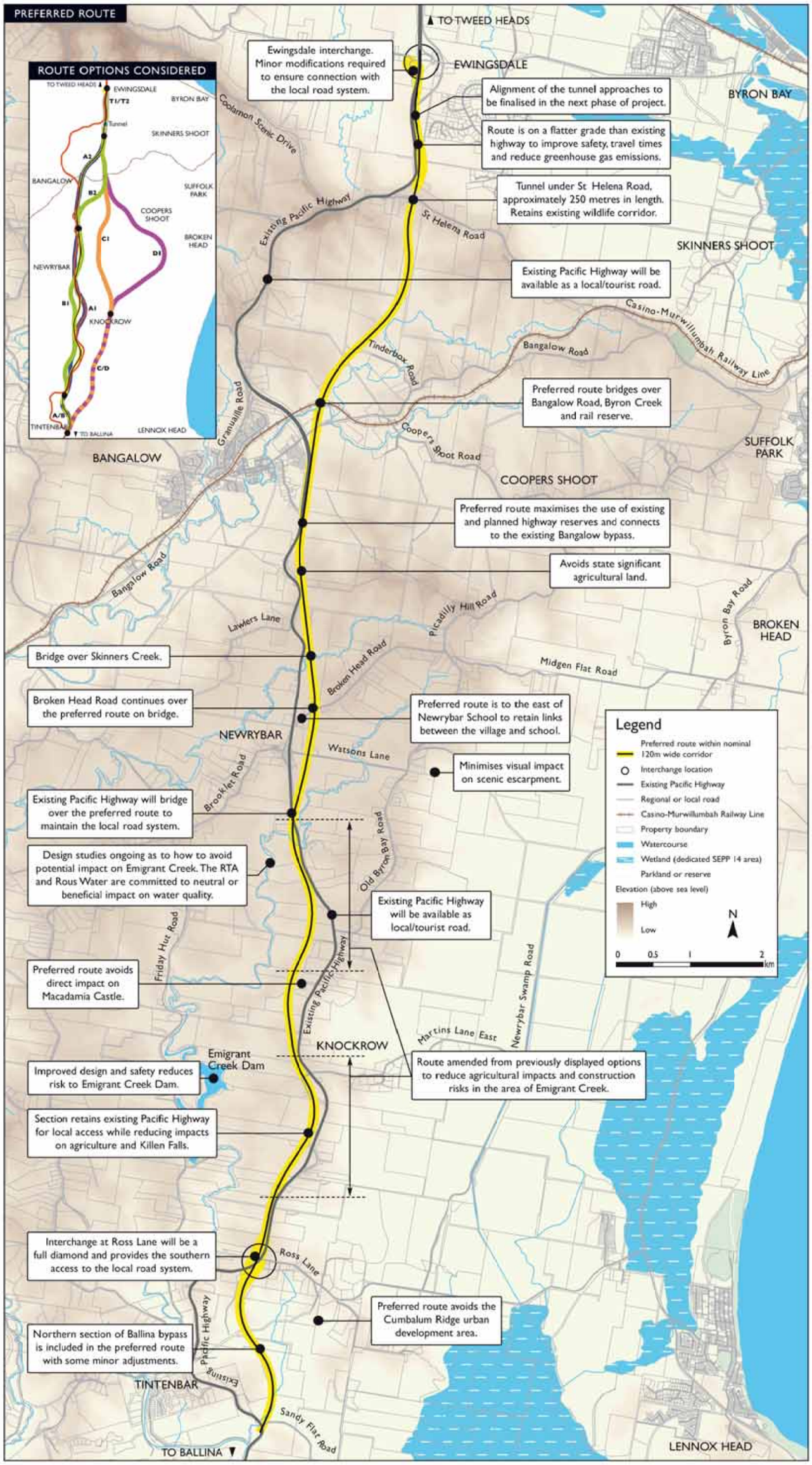
4. The assessment of the viability of residual lots is described in *Tintenbar to Ewingsdale: Upgrading the Pacific Highway - Preliminary Assessment Report on Agricultural Considerations* (RTA 2006)

5. Worth of agricultural land affected by severance is calculated using the formula described in *Tintenbar to Ewingsdale: Upgrading the Pacific Highway – Preliminary Assessment Report on Agricultural Considerations* (RTA 2006), which includes a factor for the degree of affectation.

6. Absolute Community Noise Burden (Absolute CNB) is a quantitative evaluation of potential annoyance caused by absolute traffic noise levels on residential receivers up to 500 m from the preferred route. Larger numbers imply a greater potential noise impact.

7. Relative Community Noise Burden (Relative CNB) is a quantitative evaluation of potential annoyance caused by change in noise levels at residential receivers up to 500 m from the preferred route. Larger numbers imply a greater potential noise impact (i.e. -230 represents a greater potential noise impact than -550).

Figure 8.28 Summary of Preferred Route Key Characteristics



9 Project Cost

9.1 Scope Definition

The Ross Lane to Ewingsdale section of the Pacific Highway upgrade as originally envisaged was a 15.8 km length of dual carriageway between the northern end of the Ballina Bypass at Ross Lane and southern extent of the existing dual carriageway at Ewingsdale.

Following the decision to expand the study area in April 2005, the project limits were extended to Sandy Flat Road. These adjusted limits were used to determine the comparative costs for each of the short listed options as detailed in **Chapter 3**.

Given that the route selection process has identified a preferred route which incorporates the northern end of the Ballina Bypass, it has been agreed with the RTA that the section of the Ballina Bypass between Sandy Flat and Ross Lane should remain as part of the Ballina Bypass. Therefore the project limits for the preferred route revert to the original limits between Ross Lane and Ewingsdale.

The preliminary cost estimates for the preferred route have therefore been prepared based on a preferred route which extends from Ross Lane to Ewingsdale, a length of 18.9 km on the existing highway or 17.0 km along the preferred route. The preliminary cost estimate has been prepared in accordance with the RTA's *Project Estimating Manual* (RTA Project Management Office, December 2001).

The scope of works for Tintenbar to Ewingsdale preferred route is as follows:

- Project extends from Ross Lane in the south to Ewingsdale interchange in the north.
- Class M standard, 110 km/h posted speed limit, controlled access with no at-grade intersections.
- Two lanes in each direction with a 12 m wide median which allows for the addition of a third lane in each direction.
- Carriageway width of 11.5 m at bridges and tunnel to allow addition of third lane in each direction without widening of structures. This width assumes that when the third lane is added, cyclists would be diverted onto the existing highway as an alternative route.
- Diversion or grade separation where local roads cross the proposed highway. Bridges to carry existing local roads above the upgraded highway are proposed at the following locations:
    - Ivy Lane (single 6 m wide structure about 70 m long).
    - Existing highway south of Newrybar (single 11 m wide structure about 155 m long).
    - Broken Head Road (single 11 m wide structure about 125 m long).
    - Private property access north of Skinners Creek (single 6 m wide structure about 50 m long).

Underpasses allowing local roads to pass underneath the upgraded highway are proposed at the following locations:

- 500 m south of Martins Lane West
- Watsons Lane
- Tinderbox Road

- Separation of local and through traffic by provision of a separate road for local traffic, generally the existing highway.
- No intermediate interchanges between the proposed Ross Lane interchange and the existing interchange at Ewingsdale. It is assumed that the Ross Lane interchange and south facing ramps are to be constructed as part of the Ballina Bypass. The proposal includes allowance for the

addition of north facing ramps at the Ross Lane interchange and minor modifications to the Ewingsdale interchange to allow separation of local and through traffic to the south.

- A tunnel through St Helena Hill, approximately 250 m long.
- There are six main bridges on the preferred route as follows
    - Bridge across Sandy Flat Creek (twin structures about 10 m long).
    - Bridge across unnamed creek about 300 m south of Emigrant Creek (twin structures about 90 m long).
    - Bridge across Emigrant Creek (twin structures about 120 m long).
    - Bridge across Skinners Creek (twin structures about 120 m long).
    - Bridge across Bangalow Road (twin structures about 30 m long).
    - Bridge across Byron Creek and Railway (twin structures each about 175 m long).
- Upgraded highway designed for B-Double usage but not local road connections because none of the local roads are designated for B-Double usage.
- Cross drainage designed to accommodate 1 in 100 year rainfall event.

9.2 Assumptions

The following assumptions have been made in developing the cost estimate for the preferred route:

- Bridge structures are a standard type with no allowances for long spans, landmark structures or special architectural statements.
- The project can proceed as a single large contract with no delays due to land acquisition.
- Earthworks would be adjusted during detail design to achieve an approximate earthworks balance.
- No allowance has been made for the inclusion of rest areas for heavy or light vehicles to replace the existing southbound rest area located just north of Bangalow.

9.3 Structure of Preliminary Cost Estimate

The cost estimate has been prepared in the standard RTA format which divides the project into six major cost components as follows:

- Project development (includes costs up to and including planning approval).
- Investigation and design (includes design and documentation of the approved project for construction).
- Property acquisition.
- Public utility adjustments.
- Construction (main elements are earthworks, pavements, structures and drainage. Separate allowances are made for environmental works, site management, RTA representation etc).
- Handover (includes costs associated with project completion and handover of completed assets to the relevant authority).

9.4 Risk and Contingency Allowances

Allowances for risk and contingency are included in accordance with the principles described in the *RTA Project Estimating Manual* and following consideration of the issues raised in the project risk management procedures.

At this stage a probabilistic assessment of project risks has not been carried out and contingency allowances are based on an item by item assessment of the various items making up the estimate. Allowances on individual items as well as the resulting global allowances have been reviewed by comparison with typical allowances adopted on other RTA projects with similar levels of engineering and environmental investigations and similar levels of design development.

9.5 Project Programme

After all project approvals are obtained, it is estimated that a period of about two years would be required for land acquisition concurrent with adjustments being made to public utilities, completion of detail design and investigations, and tendering procedures prior to commencement of construction.

On the assumption that construction would be carried out as one large contract, it is anticipated that the required construction period would be approximately three years.

Project completion would therefore take at least five years, at a minimum, following project approval.

9.6 Construction Methods

9.6.1 General

The construction estimate is based on application of standard construction methodology. Actual construction methods could vary depending on the chosen procurement method, the contractor and the conditions of approval by the NSW Minister for Planning, but would include the following activities for each section of the proposed works:

- Acquisition of land.
- Adjustment of existing public utilities.
- Pre-clearing investigations to confirm locations of flora and fauna of conservation significance.
- Site establishment including survey set out, safety fencing of site, and establishment of site compounds, and access points and access routes.
- Installation of traffic management measures to control highway and construction traffic during construction.
- Installation of temporary erosion, sediment and water quality controls including diversion drainage, sedimentation basins and cross-flow culverts.
- Establishment of stockpile areas.
- Clearing of vegetation and mulching of plant material for reuse.
- Stripping, stockpiling and management of topsoil.
- Treatment of any soft soil areas under embankments.
- Earthworks.
- Installation of drainage lines, fauna underpasses and local access.
- Establishment of asphalt and concrete batch plants.
- Bridge and tunnel construction.
- Subgrade preparation and pavement construction.

- Topsoil rehabilitation and revegetation of batters and berms.
- Landscaping.
- Installation of noise mitigation measures (note that, where possible, noise mitigation measures would be installed earlier in the construction process where not dependent on completion of earthworks and where they would be of benefit in reducing construction noise).
- Line marking and signposting.
- Interchange lighting.
- Completion works (including general site clean up and removal of site compounds).

9.6.2 Earthworks

It has been assumed that a haul road would be established along the route corridor to allow efficient and safe haulage of material using bulk handling equipment.

The preliminary geotechnical investigations have identified that there are five cuttings where blasting is likely to be required. The investigations also indicate that excavated material would be suitable for general fill and with crushing would also provide material suitable for pavements and select fill.

Considering the scale of the project, the volume of earthworks and the type of material expected, establishment of site crushing and batching plants is likely to be cost effective and has been assumed.

9.6.3 Pavements

Concrete pavement has been assumed for the purposes of the cost estimate. Allowance is included for the addition of a layer of low noise road surfacing in areas with a concentration of dwellings.

Soft soils are not a significant issue for the shortened section from Ross Lane to Ewingsdale and plain concrete pavement has been assumed, comprising a 250 mm concrete base over a 150 mm concrete sub-base.

Considering the scale of the project and the type of material expected, establishment of site crushing and batching plants is likely to be cost effective and has been assumed.

9.6.4 Bridges

There are no major bridges across large waterways and it is anticipated that all bridge structures would be standard structures without long spans or any special architectural statements.

Most of the larger bridges could be constructed free of traffic, the exceptions being the existing highway bridge above the upgraded highway just south of Newrybar and the bridge carrying Broken Head Road above the upgraded highway near Newrybar which could both be constructed using top-down techniques. Construction of the bridge across Bangalow Road would require construction above an operating roadway.

9.6.5 Tunnel

Preliminary geotechnical investigations indicate that the tunnel would be through the Lismore Basalt which generally comprises relatively competent high strength basalt separated by more weathered and fractured basalt layers.

Tunnel construction would adopt techniques used previously in NSW. Twin tunnels with an arched roof profile and a rock pillar separating the tunnels are expected to be suitable considering the ground conditions, similar in profile to the recently constructed Cudgen Road Tunnel. Tunnel excavation would use conventional drill and blast techniques.

The tunnel is not expected to significantly affect the existing groundwater regime and a drained tunnel (unlined) is proposed. Rock bolts and shotcrete would be utilised to provide the primary and permanent tunnel support along with pre-grouting to reduce the permeability of the rock and strengthen the rock mass.

9.7 Preliminary Cost Estimate for Preferred Route

The preferred route is made up route sections A/B, A1-a, B1-b, B1-c, A2 and T2. A number of minor adjustments and refinements have been made in combining the sections, particularly at the nodes where the sections join.

The preliminary cost estimates are based on detailed quantities derived from the 3D model of the collated sections making up the preferred route. All access roads have also been modelled in 3D to confirm the feasibility and extent of providing required local access.

The preliminary cost estimate has been prepared in accordance with the RTA *Project Management Guidelines for Estimating, Scope and Cost Control for Development Projects* (Version 3, RTA 2000). The estimates are based on typical construction contract rates and on quantities derived from the preliminary concept design of the preferred route.

The construction cost estimate has been developed by applying unit rates to the derived quantities. The unit rates are based on historical data, with care taken to ensure that the adopted rates reflect similar work items and are corrected as required for inflation and site conditions. Rates are inclusive of contractor overheads and profit.

The estimate has been prepared using the current concept design; it will undergo value engineering and further refinement in the project approval process.

The estimated total project cost for the preferred route is $368 million at March 2006 costs. The estimate is summarised in **Table 9.1**.

Table 9.1 Preliminary Cost Estimate for Preferred Route*

Item	Base Estimate (excluding contingency) ($M)	Contingency		Final Estimate (including contingency) ($M)	% of Total
		%	Amount ($M)		
Project Development	13.2	35.2%	4.7	17.9	4.9%
Investigation and Design	7.6	35.0%	2.7	10.3	2.8%
Property Acquisitions	24.7	94.3%	23.3	48.0	13.1%
Public Utility Adjustments	7.5	70.0%	5.2	12.7	3.5%
Construction	210.2	29.5%	61.9	272.1	74.0%
Handover	4.8	35.0%	1.7	6.5	1.8%
TOTAL	**268.0**	**37.1%**	**99.5**	**367.5**	**100.0%**

* Costs exclude the Ballina Bypass section.

The preliminary cost estimate of $368 million for the preferred route is slightly less than the comparative cost estimate of $385 million presented in **Table 3.16** (and **Appendix C**) for Option 25 which became the preferred route. The difference is a result of adjustments which have been made in preparing the preferred route estimate as follows:

- As noted in **Section 9.1**, the preferred route estimate is for the length between Ross Lane and Ewingsdale and excludes the section of the Ballina Bypass between Sandy Flat and Ross Lane.

- In combining sections A/B, A1-a, B1-b, B1-c, A2 and T2, a number of minor design adjustments and refinements have been made, particularly where the sections connect to each other. Generally these adjustments and refinements have slightly reduced the estimated cost.
- Contingency allowances have been increased from 30% to 37% overall, in line with RTA policy.

9.8 Reality Check of Preliminary Cost Estimate

Reality checks for the estimates are provided in **Table 9.2**.

Table 9.2 Reality Check for Preliminary Cost Estimate

Project Cost / km	$21.6 M
Project Cost / lane-km	$5.4 M
Earthworks Cost / m3	$18
Pavement cost / m2	$159
Structure cost / m2 deck area	$3,280

Project costs are high on the per km and per lane km measures compared to other RTA projects but reflect the cost of the tunnel (excluding the tunnel the project cost/km is about $18.2 M.) Other costs appear reasonable given that the rates include contingency allowances.

9.9 Economic Analysis

An economic analysis for the preferred route between Ross Lane and Ewingsdale has been completed using the RTA's Rural Evaluation System (REVS) road user cost benefits analysis model.

The results of this analysis indicate the preferred route is economically justified with the following results:

- Benefit Cost Ratio (BCR) of about 1.6.
- Internal rate of Return (IRR) of about 10%.

10 Next Steps

10.1 Detailed Concept Design

The preferred route discussed in **Chapter 1** is based on an initial concept design. This concept design is being continually refined to improve functionality and safety in a manner that minimises social and environmental impacts. This ongoing refinement of the preferred route will continue as the project progresses and will include consideration of more detailed aspects of the proposed upgrade, including the alignment of Sections A1-a and B1-b. The detailed concept design will be coordinated with the additional investigations and environmental assessment outlined in **Section 10.2**.

As the concept design is being developed, it is addressing some important identified issues. It is expected that discussions with affected landowners, additional investigations and refinements in the earthworks balances would cause further adjustments prior to the formal application to the Department of Planning for project approval. Some key issues that will need to be addressed are:

- Noise: The preferred route is located near the more densely populated sections of the study area. As such, careful attention will need to be placed on the geometric design to ensure that noise impacts are minimised.
- Agricultural Impacts: Issues such as access, ground and water sources and development restrictions will also need careful attention in the concept design development.
- Impacts on Housing: There will be disruption to residential properties along the preferred route. There will also be dwellings that will be close to the upgraded Highway but not directly impacted, that will require close attention in the final configuration and during construction.
- Newrybar School: The school will have the new Pacific Highway to the east in a considerable cutting to allow Broken Head Road to pass via a bridge over the upgraded Highway. The proximity of the preferred route to the school and subsequent location of the school between two major roads (old and new Pacific Highways) is an important issue. Ongoing consultation between the Project Team, the school, and the school community will focus on amenity, safe accessibility, and the integrity of the school.
- Tunnel: The T2 alignment and tunnel design will require further refinement in the next phase.

10.2 Environmental Assessment of Preferred Route

Following the announcement and public display of the preferred route for the Tintenbar to Ewingsdale Pacific Highway upgrade project, the RTA intends to submit an application with the Department of Planning seeking approval of the project in accordance with Part 3A of the EP&A Act. The Minister for Planning would decide whether the project would be approved or refused.

Additional studies, including geotechnical and ecological investigations, and further detailed assessment of the project, would be undertaken as part of the continued refinement of the preferred route, and the preparation of an environmental assessment for the project. Consultation with affected landowners and the broader community would also continue during the preparation of the environmental assessment.

The scope and level of detail required in the environmental assessment will be set by the Director-General of the NSW DoP, in consultation with the relevant Government agencies and local Councils.

Once it is completed and accepted by the NSW DoP, the environmental assessment will be publicly exhibited and submissions sought. The RTA would be required to consider and respond to the issues raised in submissions, and may also need to consider modifications to the project to minimise environmental impacts. The NSW DoP may require such modifications to be reported in a preferred project report, and made publicly available.

The NSW DoP would assess the environmental assessment (including any modifications), and the Director-General of the Department would prepare a report for the Minister providing the outcomes of that assessment, so that the Minister can duly consider the project.

Abbreviations

Abbreviation	Definition
AADT	Annual Average Daily Traffic
AADV	Annual Average Daily Vehicles
Absolute CNB	Absolute Community Noise Burden
AEP	Annual Exceedance Probabilities
AFG	Agricultural Focus Group
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment Conservation Council
BCR	Benefit Cost Ratio
CCD	Census Collection District
CLG	Community Liaison Group
CNB	Community Noise Burden
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CoRTN	Calculation of Road Traffic Noise
dB	Decibel
DCP	Development Control Plan
DEC	NSW Department of Environment and Conservation (formerly NSW EPA and NSW National Parks & Wildlife Service)
DIPNR	Department of Infrastructure, Planning and Natural Resources (now Department of Planning and Department of Natural Resources)
DoP	NSW Department of Planning (formerly part of DIPNR)
DPI	NSW Department of Primary Industries (formerly NSW Fisheries, State Forests NSW and NSW Agriculture)
DoNR	NSW Department of Natural Resources (formerly part of DIPNR)
ECRTN	Environmental Criteria for Road Traffic Noise (DEC)
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EPA	NSW Environment Protection Authority (now part of NSW DEC)
EPBC Act	Commonwealth Environment Protection Biodiversity Conservation Act 1999
ESD	Ecologically Sustainable Development
GRP	Gross Regional Product
ha	Hectare
km	Kilometre
kV	Kilovolt
LEP	Local Environment Plan
LALC	Local Aboriginal Land Council

Abbreviation	Definition
LGA	Local Government Area
lin, peak	Linear weighted, peak sound pressure level
LOS	Level of Service
m	Metre
Mg/m^3	Milligram Per Cubic Meter
$\mu g/m^3$	Microgram Per Cubic Meter
MVK	Million Vehicle Kilometres Travelled
NAASRA	National Association of Australian State Road Authorities (now AUSTROADS)
NO	Nitric Oxide
NO_x	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
NPW Act	The National Parks and Wildlife Act 1974
NRRDB	Northern Rivers Regional Development Board
PAD	Potential Archaeological Deposit
PAH	Poly-Aromatic Hydrocarbon
PHUP	Pacific Highway Upgrading Program
PM_{10}	Particulate Matter (smaller than 10 micrometers in diameter)
$PM_{2.5}$	Particulate Matter (smaller than 2.5 micrometers in diameter)
ppm	Parts per Million
PPV	Peak Particle Velocity
Relative CNB	Relative Community Noise Burden
REP	Regional Environmental Plan
RNE	Register of National Estate
RODR	Route Options Development Report
RTA	NSW Roads and Traffic Authority
SEPP	NSW State Environmental Planning Policy
T2E	Tintenbar to Ewingsdale Pacific Highway Upgrade Project
TSC Act	NSW Threatened Species Conservation Act 1995
VMW	Value Management Workshop

Glossary of Terms

Term	Definition
Aboriginal Heritage Information Management System	A list of known Aboriginal sites held by the DEC.
Absolute Community Noise Burden (CNB)	Absolute Community Noise Burden (ACNB) is a quantitative evaluation of potential annoyance caused by absolute traffic noise levels on residential receivers up to 500 m from the preferred route. Larger numbers imply a greater potential noise impact.
Acid Sulfate Soils (ASS)	Naturally acid clays, mud and other sediments usually found in swamps and estuaries. They may become extremely acidic when drained and exposed to oxygen, and may produce acidic leachate and runoff, which can pollute receiving waters and liberate toxins. ASS is classified as material, which is above the groundwater, is undergoing oxidation and has a pH of less than 4.0.
Afflux	The maximum difference in water level caused by a structure (such as a bridge or culvert) in relation to the “without structure” flow condition.
Alignment	A detailed geometric layout, in plan and profile, following a general route.
Amenity	Natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence and cultural and recreational attributes.
Annual Exceedance Probability (AEP)	The chance of a flood of a given size (or larger) occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (i.e. a 1 in 20 chance) of a peak discharge of 500 m^3/s (or larger) occurring in any one year.
Archaeological Site	A site is defined as any material evidence of past Aboriginal activity that remains within a context or place that can be reliably related to that activity. Usually a site classification requires a minimum of two detected artefacts.
Annual Average Daily Traffic (AADT)	Volume representing the total traffic in both directions at each location, calculated from mechanically obtained axle counts.
Annual Average Daily Vehicles (AADV)	Represents the average number of vehicles passing in both directions during a 24-hour period estimated over a period of one year.
B-Double vehicle	Heavy transport vehicles that are 17.5 m to 36.5 m long, and have six or more axles in four groups. They are classified as Class 10 under the AUSTROADS vehicle classification system.
Barrier	An obstruction placed to prevent vehicle access to a particular area. This includes structures whose prime purpose is to restrain and/or redirect in a controlled manner vehicles which are out of control.
Batter	The side slope of walls, embankments and cuttings or the degree of such slope.
Benefit Cost Ratio (BCR)	The ratio of the present value of benefits to the present value of costs of a project.
Biological Diversity (Biodiversity)	The range and relative abundance of plant and animal life in a nominated area.

Term	Definition
Biota	Animal and plant life characterising a particular region or flora and fauna collectively.
Blackspot	An intersection, mid-block or short road section with a history of at least three casualty crashes over a five year period.
Buffer	Something that lessens or absorbs an impact.
Carriageway	Portion of a road or bridge used by vehicles (inclusive of shoulders and auxiliary lanes).
Census	The enumeration of an entire population, usually with details being recorded on residence, age, sex, occupation, ethnic group, marital status, birth history, and relationship to head of household.
Climbing Lanes	An auxiliary lane, usually on a long upgrade, primarily for the use of slow-moving vehicles. They differ from overtaking lanes in that the linemarking does not initially direct all traffic to the left hand side of the road.
Census Collection District (CCD)	The areas designed for use in census years for the collection and dissemination of Population Census data
Community Noise Burden (CNB)	A measure of the potential annoyance caused by traffic noise levels on residential receivers.
Culvert	An enclosed channel used for the passage of surface water under a road or other embankment.
Cut (batter)	The material removed (excavated) from the existing ground surface.
Decibel (dB)	A unit used in the comparison of powers and levels of sound energy. A comprehensive glossary of noise terms can be found in Section 1 of the RTA's *Environmental Noise Management Manual* (2001), which can be obtained from RTA's website at www.rta.nsw.gov.au/environment/noise/.
dB(A)	Decibels using the 'A' weighted scale, measured according to the frequency of the human ear.
Demographic	Of or pertaining to population, especially in statistical terms.
Design speed	A nominal speed used for the design of geometric features of the road, such as curves.
Dispersion	The spatial property of being scattered about over an area or volume.
Dual carriageway	A road with separated carriageways for traffic travelling in each direction.
Earthworks	The process of extracting, moving and depositing earth during construction.
Ecologically Sustainable Development (ESD)	Development that maintains and improves the total quality of life. Development both now and in the future in a way that maintains the ecological processes on which life depends. Key components of ESD are intergenerational equity, maintenance of biodiversity, improved economic evaluation of environmental costs and benefits and the precautionary principle.
Ephemeral	Watercourse which flows after heavy rain, and dries up during fine weather.
Evaluation Criteria	A list of criteria and measurables used to evaluate the route options. Sieve 1 criteria were used to evaluate the long list of options. Sieve 2 criteria were used to evaluate the shortlist of options.

Term	Definition
Fill (batter)	The material placed in an embankment.
Floodplain	Valley floor flat adjacent to a stream that is flooded by the 'annual' flood (often considered to be the flood with a recurrence interval of about 1.6 years).
Footprint	The footprint is indicative of the likely actual road reserve width requirements and includes the land that would be required for the physical roadway (highway and service roads), public utility plant (if required), earthworks, and maintenance clearances. The footprint also includes a margin for drainage or other works that may be required beyond the extent of earthworks.
Geotechnical	Work relating to soil mechanics, foundation engineering, rock mechanics, engineering geology, hydrogeology and materials testing.
Grade Separation	The separation of traffic so that crossing movements that would otherwise conflict are at different levels.
Groundwater	Water beneath the surface of the earth which saturates the pores and fractures of sand, gravel, and rock formations.
Habitat	The place where an organism lives, habitats are measurable and can be described by their flora and physical components.
Horizontal Alignment	The geometric form of the centreline of a roadway in the horizontal plane.
Hydraulic	Related to water and the flows and pressures within a connected water-containing system.
Hydrologic	Dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks and in the atmosphere
Interchange	A grade separation of two or more roads with one or more interconnecting carriageways or ramps.
Intersection	A meeting of two or more roads.
Littoral	The shallow, shoreward region of a body of water sometimes inhabited by aquatic plants.
L_{eq}	The ‘equivalent continuous’ noise level over the measurement period (sometimes called the ‘average’ noise level). This is a notional steady level, which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period.
Level of Service	A qualitative analysis providing a means of determining the traffic-carrying performance of a road or any element of it under the prevailing roadway and traffic control conditions.
Median	A strip of land which separates carriageways for traffic in opposite directions.
National Highway	A highway that has been declared a National Highway by the Federal Government.
Noise Wall	A wall or barrier (noise barrier) erected to block or deflect noise.
Oxidation	The chemical process of oxygen combining with an element or compound (e.g. the oxidation of iron to form rust).

Term	Definition
Pairwise	A tool used to assess the relative importance of the evaluation criteria. It allows stakeholders the opportunity to weight the evaluation criteria in order of importance to them. This allows the study team to gain an understanding of which evaluation criteria are viewed as more important.
PM_{10}	Usually airborne particulate matter less than 10 μm (microns or one millionth of a metre) in diameter, a measure of dust.
$PM_{2.5}$	Usually airborne particulate matter less than 2.5 μm (microns or one millionth of a metre) in diameter, a measure of dust.
Portal	Entry and/or exit of a tunnel.
Potential Acid Sulfate Soil (PASS)	Defined as material below the groundwater which has not been oxidised and generally has a pH of greater than 4.0. The pH has the potential to become much lower when the soil is exposed to oxygen as a result of activities such as excavation and drainage.
Preferred Route Corridor	'Footprint' plus a margin added to the 'footprint' for future design refinement.
Relative Community Noise Burden (CNB)	Relative Community Noise Burden (RCNB) is a quantitative evaluation of potential annoyance caused by change in noise levels at residential receivers up to 500 m from the preferred route. Larger numbers imply a greater potential noise impact (i.e. – 230 represents a greater potential noise impact than – 550).
Service Road	A subsidiary carriageway constructed between the principal carriageway and the property line, connected only at selected points with the principal carriageway. It reduces the number of access points to a major road, with a consequent improvement in safety.
Shotcrete	Mortar or concrete sprayed using compressed air onto a disturbed surface to stabilise against erosion.
Shoulder	The strip of pavement bordering the carriageway beyond the traffic lanes and constructed at the same level as the pavement surface. Used by traffic in emergencies and provides clearance to batter slopes.
Sieve 1	A system used to evaluate the long list of options and assist in selection of the shortlisted route options. The long list of route options are scored individually against a range of Sieve 1 selection criteria. These scores are then weighted according to the relative importance of each selection criteria as determined by the Sieve 1 pairwise process and then summed to determine a relative score for each option.
Sieve 2	A similar system used to evaluate the shortlist of options and assist in selection of the preferred route. Shortlisted options are scored individually against the Sieve 2 selection criteria.
State Highway	A main road that is a principal avenue of road communication between the east coast and the interior or otherwise within the State and connecting similar roads in other States.
Quaternary	The geologic time period comprising about the last 1.65 million years.
Terrestrial	Living or growing on land; not aquatic.
Tributaries	Rivers or streams flowing into a larger river or lake.
Vertical Alignment	The geometric form of the centreline of a carriageway in the vertical

Term	Definition
	plane.
Viaduct	A long bridge, generally composed of a series of spans over land, which carries a road or railway.
Wetland	Land either permanently or temporarily covered by water. These areas are usually characterised by vegetation of a moist-soil or aquatic type.

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Appendix A

Community Liaison Group Issues

A1 Community Liaison Group Issues

Issue/Concern	Raised/Requested By	Project Team Response
Size of Original Study Area: East-west dimensions of original study area were considered inadequate to address a range of issues within the study area. It was felt that there may be feasible options outside of the existing study area.	Community members at the Community Information Sessions (CISs) in October 2004, and original CLG members	Conducted Study Area Review as a result of community and CLG input. The results of this review led to expansion of the study area to the east and south. The size of the expanded study area allowed for the development of numerous feasible route options, leading to the selection and assessment of 13 options in the long list of route options.
Overall Community Input on Constraints Identification and Mapping: The community requested input to the decision making process.	Community members at CISs in October 2004	The project team held workshops sessions at the three CISs held in October 2004. This input was used in the development of the constraints and objectives for the project. The constraints and objectives are key elements in the decision-making process of the location of route alignments. Information received at the CISs was documented in detail and made available to the CLG and the public via the project website. Note: CIS sessions held in April 05 for the extended study area were also designed with workshops, however community members in attendance chose to have an extended question and answer session instead. Following the question and answer session, the community was again offered the opportunity to map constraints and possible route alignments; several community members chose to participate in this activity facilitated by project team members. This information was summarised, reported and used in the constraints mapping and development of route options.

Issue/Concern	Raised/Requested By	Project Team Response
Project Objectives: Project objectives proposed at beginning of study did not address issues of local concern (particularly agricultural, environmental and community input) and need to be expanded	Community members at CIS in October 2004, and CLG members	The original group of CLG members were actively involved in generating the revised and expanded list of project objectives which were adopted for the project. At the request of the CLG, project objectives we discussed at length at the initial CLG meetings. New members of the re-formed CLG group (organised after the expansion of the study area) also had the opportunity to review the project objectives. The final list of objectives was considered by the CLG. The resulting list of objectives was more comprehensive than the original and included specific local concerns. Thus there was significant CLG input into the objectives that have driven the route option development process.
Independent Facilitator for CLG: The CLG was concerned that because the RTA sets the agenda and runs the meetings that there would be a lack of transparency/fairness in the CLG process; they requested that an independent facilitator be appointed to run the CLG meetings	CLG	An independent facilitator was on board to manage the CLG meetings by the 5th CLG meeting. As of mid-March 2006, 16 CLG meetings have been held.
Evaluation Criteria: Concern that local issues were adequately addressed in the assessment process	CLG and AFG	The evaluation criteria were the subject of extensive discussion at several CLG meetings (discussed during at least 3 CLG meetings and 1 AFG meeting).The re-formed CLG had substantial input in the resulting list of evaluation criteria adopted for the assessment of the long list of route options. The AFG also had the opportunity to review and comment on the evaluation criteria.

Issue/Concern	Raised/Requested By	Project Team Response
CLG Input on Development of Route Options: Concern that CLG would not have relevant input on the development of route options	CLG	Draft constraints mapping was presented to the CLG by various project team specialists in June 2005. Presentations were made on geotechnical issues, highway engineering design criteria, traffic, terrestrial ecology, aquatic ecology, landscape and visual, agriculture and land use, cultural heritage and hydrology. The CLG was able to question the specialists and comment and add to the constraints. The resulting constraints maps were a fundamental tool used in the identification of feasible options. Thus the CLG had the opportunity to provide valuable input in the development of the route options.
Noise Issues: The CLG requested a special noise briefing	CLG	A CLG noise briefing was held in June 2005. This generated a noise question and answer spreadsheet which provided two-way communication between the project team and the CLG. Comments and questions provided by the CLG were beneficial in contributing to the project team's understanding of community concerns.
Weighting of Evaluation Criteria and Assessment of Long List: Concern that assessment of the long list include community input	CLG	All members of the CLG participated in the pairwise analysis of the evaluation criteria. The results of this input were used as a sensitivity test of the project team's weightings. Application of the CLG pairwise results did not change the outcome of the assessment of the long list and the recommended short list. It should be noted that several members of the CLG felt the results of the CLG pairwise exercise reflected that the CLG was not representative of the community and that the results should not be used in any analysis of the options.
Input on Development of Route Options: Concern that community concerns have little weight in the RTA's decision-making process	CLG and AFG	The CLG was given the opportunity to propose their own route options for assessment (draw lines on maps). The CLG however felt that it would be more appropriate to developed lists of advantages and disadvantages associated with the RTA's long list of route options. These advantages and disadvantages were reviewed by the project team and taken into consideration in the assessment of the long list of route options.

Issue/Concern	Raised/Requested By	Project Team Response
CLG Bus Tour: The CLG requested a briefing on the short list of route options in order to provide feedback to the project team	CLG	The project team organised a bus tour for the CLG members. Project team members accompanied the tour in order to provide clarification of the route alignments. During and after the tour, CLG members provided detailed feedback on the impacts of the short list of route options to the project team. This input was used in the refinement of the short list of route options and assessment of the short list.
Participation in Corridor Assessment Workshop (CAW) and Value Management Workshop (VMW): Concern that community concerns have little weight in the RTA's decision-making process	CLG and AFG	The CLG had representatives at the CAW and the VMW. The AFG was represented at the VMW. (These representatives were selected by the CLG and AFG members.) The CAW and the VMW are one 'stream' of the decision making process; reports from these workshops are provided to the Minister of Transport to be used in the decision making process for the preferred route. The CLG and AFG representatives had the opportunity to present community issues and concerns to all participants at these workshops which included senior RTA personnel and agency representatives. Opportunities were provided for open debate on sensitive local issues. Input received from the CLG and AFG members was documented in reports for these workshops. This information is reviewed by all relevant agencies, the Minister and senior RTA personnel. Therefore the representatives have had the opportunity to communicate concerns to all involved in the decision-making process.
More Detailed Agricultural and Economic Impact Studies: Concern that the Route Options Development Report did not adequately address agricultural and local and regional economic impacts	CLG and AFG	Hassall and Associates were added to the project team to address agricultural and economic issues. A detailed survey was posted to every property owner potentially 'directly impacted' by the short list of route options. This survey will form part of the Hassall report. The Hassall report will be reviewed with the CLG and AFG. Outcomes of this report will be used in the assessment of the short list of route options.
Noise Impacts at Ewingsdale: Concern that Ewingsdale community has input on the tunnel approach option	CLG member and Ewingsdale Community	Meetings were held with the Ewingsdale community to discuss noise impacts and potential mitigation.

Issue/Concern	Raised/Requested By	Project Team Response
Public Display Locations: The CLG was concerned that information about the Route Options should be made available to communities outside the study area such as Byron Bay, Lennox Head and Broken Head.	CLG	The CLG provided input on possible display locations for the Route Options Display. A number of these suggestions were adopted and included in the display.
On-going Communication: Requests for information and clarification on the project, and daily access to the project team	CLG and Community	Maintained the project information (freecall) line and email throughout the route development process. The CLG and the community could contribute with submissions and comments throughout the study. Their comments were distributed to the project team for reference as the project progressed. Where required, written responses were provided by the project team.

Appendix B

Sieve 2 Evaluation Criteria

B1 Sieve 2 Evaluation Criteria

Sieve 2 Criteria	Sieve 2 Measurable	Comments
Safety and Functionality		
Travel Efficiency	Travel time along Pacific Highway upgrade	Measure of the highway travel time (minutes) for all light and heavy vehicles based on a maximum allowable speed of 110 km/h. Higher performing options have the lowest travel time in minutes for light vehicles and heavy vehicles.
	Local road network accessibility	Qualitative appraisal considering changes in travel time/distance for local traffic within the study area (based on the local road network proposed with each option). Local traffic is defined as trips having an origin and destination within the study area.
Improve Safety	Accident rates	Qualitative comparison based on the number of safety deficiencies identified in the road safety audit.
	Length through potentially fog prone areas	This criterion is based on community reported fog mapping. Higher performing options have the least length of highway (km) in fog prone area.
Hydrology and Flooding	Length of route within 1% Annual Exceedance Probability (AEP) flood extent.	Extent of 1% AEP flood event mapped using information from a number of sources including Councils (Byron Shire, Ballina Shire and Richmond River County) and the DIPNR floodplain mapping. Higher performing options have a shorter length (km) within the extent of the 1% AEP flood event.
Buildability	Ability to Stage Construction	The extent to which the route option alignment allows sections to be constructed and opened to traffic as stand alone sections of upgraded highway. This identifies the potential for shorter sections of highway to be constructed and opened; thus allowing benefits such as safety to accrue earlier compared to an operating start date of the full length of the option.
	Disruption to traffic during construction	Length of route option to be constructed on or immediately adjacent to the existing Pacific Highway. Higher performing options have the shortest length.

Sieve 2 Criteria	Sieve 2 Measurable	Comments
Buildability cont.	Construction Risks	Qualitative appraisal considering: – Total length of major structures (bridges or drainage structures with a length >30m) – Length of route through areas of geological instability – Affect on springs (total number of known springs directly affected and number of springs in double sided cuts) – Length of route through acid sulphate soils – Length of route through soft soils – Preliminary imbalance of earthworks. Higher performing options are less likely to require imported material. – Number of dwellings within 100m of the outer edge of the footprint: provides an indication of requirements for noise, dust, air quality, traffic and light spill mitigation. Higher performing options have the least amount of construction risk.
Social and Economic		
Economic Impact on Agricultural Businesses	Reduction in worth of agricultural land and improvements	Worth is based on market value of land, severance impacts, value of infrastructure and recognised income earning assets. Higher performing options have least reduction in agricultural worth.
Impacts on Northern Rivers Regional Economy	Loss of output to regional economy from changes in agricultural land use	Economic loss calculated using multipliers from TEDC Economic Model for Northern Rivers. Higher performing options have the least loss of output.
Impacts on Local Economy	Qualitative assessment of economic impacts on local businesses	A qualitative assessment of the local business impacts. Higher performing options have the least local business impacts.
Impacts on Residential Areas	Total number of dwellings within footprint that would be acquired (social impacts)	The higher performing options have a lower number of dwellings to be acquired. This correlates to less social disruption. Distinction drawn between the dwellings that are already located within the vicinity of the existing highway and those that are not (i.e. beyond 200m of existing).
	Number of dwellings within footprint that would be acquired but are located beyond 200m of the existing Pacific Highway (social impacts)	
	Value of rural residential lost (economic)	Based on market value. Higher performing options have the least effect on rural residential value.

Sieve 2 Criteria	Sieve 2 Measurable	Comments
Impacts on Residential Areas cont.	Number of existing contiguous settlement areas severed	The number of times the route severs a recognised settlement. A contiguous settlement is defined as an area where there is a cluster of residences with linkages between those residences.
	Area of planned future residential development land directly affected	Quantified as the area (ha) of future residential development land.
Noise	Noise - Absolute Community Noise Burden	This is a quantitative evaluation of potential annoyance caused by absolute traffic noise levels on residential receivers within 300-500m of the route option. The modelling takes into account all natural terrain features. A 3-d model is used and calculations are made at individual residences.
	Noise - Relative Community Noise Burden	This is a quantitative evaluation of potential annoyance caused by change in noise levels at residential receivers within 300-500m of the route option. The modeling takes into account all natural terrain features. A 3-d model is used and calculations are made at individual residences. Note: there is a correlation between this criterion and potential changes in property value. It can therefore be recognised as a proxy for potential property value change.
	Length of steep grades (exceeding 3%)	Incorporates results of noise study which indicates a rise in Lmax when grades exceed 3%. Higher performing options have the least length of steep grades.
	Number of houses where noise levels would exceed the ECRTN target criteria	The number of houses impacted based on DEC's Environmental Criteria for Road Traffic Noise.
Lifestyle	Proximity to highway	Number of dwellings, businesses and community facilities (including the Newrybar school) located within 100m of a route option (based on the footprint).
Landscape & Visual Amenity	From point of view of resident / visitor	Assessment of sensitive landscapes, and viewers that would be sensitive to changes in the visual environment.
	From point of view of driving experience	From a driver/passenger perspective, certain parts of the study area are more visually interesting than others. This criterion compares driving experience.

Sieve 2 Criteria	Sieve 2 Measurable	Comments
Natural and Cultural Environment		
Terrestrial Ecology	EECs and other high value vegetation or habitat patches directly affected	Number and area of Endangered Ecological Communities (EEC's) and other high value vegetation or habitat patches directly affected. This criterion accounts for potential affects to flora and fauna including threatened and endangered species and territorial animals. High value is placed on these EECs and areas of high value vegetation regardless of size or location. Higher performing options have a lower number and area (ha) impacted.
	Medium value vegetation or habitat patches directly affected	Number and area of medium value vegetation or habitat patches directly affected. Higher performing options have a lower number and area (ha) impacted.
	Number of 'edges' created through remnant and regenerated habitat areas	'Edges' and not 'area' is used as the criterion because of the significance of creating more edges in remnant or regenerated habitat areas. The more 'edges', the more degradation of the habitat. Higher performing options have a lower number of 'edges' created.
	Impact on wildlife corridors	Number of times regional and sub-regional wildlife corridors are crossed. Regional and sub-regional environmental corridors are considered separately in regards to the higher environmental value placed on regional corridors. Higher performing options have the least number of wildlife corridor crossings.
Aquatic Ecology	Impact on waterways (high value)	Number of high value waterways affected. The waterways have been assigned high values accounting for: good quality fish habitat, fish passage, occurrence of threatened and protected species, sensitive and protected habitat, water quality and watercourse crossings. Higher performing options have a lower number.
	Impact on waterways (medium value)	Number of medium value waterways affected. The waterways have been assigned medium values in regards to: fish habitat, fish passage, threatened and protected species, sensitive and protected habitat, water quality and watercourse crossings. Higher performing options have a lower number.
	Impact on waterways (low value)	Number of low value waterways affected. The waterways have been assigned low values due to poor fish habitat, fish passage, water quality and biodiversity.

Sieve 2 Criteria	Sieve 2 Measurable	Comments
Heritage	Impact on Indigenous sites	Assessment made regarding; – Number of indigenous sites of national significance – Number of indigenous sites of state or regional significance – Number of indigenous sites of local significance – Area (ha) of potential for archaeological deposits (PADs) directly affected Higher performing options have a lower number and indicate lesser disturbance of indigenous heritage sites.
	Impact on non-Indigenous sites	Assessment made regarding; – Number of non-indigenous sites of national significance – Number of non-indigenous sites of state or regional significance – Number of non-indigenous sites of local significance Higher performing options have a lower number and indicate lesser disturbance of cultural heritage sites.
Air Quality	Reduction in Greenhouse Gas emissions compared to 'do nothing' scenario	Calculations based on fuel usage savings compared to existing highway. Savings calculations are a factor incorporating the grade and length of proposed route section. Higher performing options have the greatest calculated GHG emissions saving.
Drinking Water Quality	Risks of disturbance to Emigrant Creek drinking water catchment	Quantitative assessment regarding length of route option through Emigrant Creek drinking water catchment; length within 40m of Emigrants Creek; and relative proximity to Emigrant Creek Dam. Higher performing options have the least length through catchment and minimise the proximity to Emigrant Creek and Dam.
	Risks of disturbance to proposed Lismore Water Source catchment	Quantitative assessment regarding length of route option through proposed Lismore Water Source catchment. Higher performing options have the least length through the proposed catchment.
Surface & Groundwater	Effect on springs	Quantitative assessment considering the number of springs known or likely to be directly. Special consideration given to springs that would be impacted by double sided cuts. The higher performing options have the least number of springs affected.
	Area of catchments requiring diversion	A measure of the area where runoff would be directed from its natural path into an adjacent catchment. Higher performing options have the least area of catchment requiring diversion.

Appendix C

Comparative Cost Estimates for Short List of Route Options

Comparative Cost Estimate for Short List of Route Options ($ million)

Option Number	Option A / T1															Option B / T1	Option C / T1	Option D / T1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Option Sections	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	C/D	C/D
	A1a	B1a	A1a	B1a	B1a	A1a	A1a	B1a	A1a	B1a	A1a	B1a	B1a	A1a	A1a	B1a	C1	D1
	A1b	A1b	B1b	B1b	A1b	A1b	B1b	B1b	A1b	A1b	B1b	B1b	A1b	A1b	B1b	B1b	T1	T1
	A1c	A1c	A1c	A1c	B1c	B1c	B1c	B1c	A1c	A1c	A1c	A1c	B1c	B1c	B1c	B1c		
	A2	A2	A2	A2	A2	A2	A2	A2	B2	B2	B2	B2	B2	B2	B2	B2		
	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1		
Length of Section (km)	18.73	18.66	18.65	18.58	18.69	18.76	18.68	18.61	19.02	18.95	18.94	18.87	18.98	19.05	18.97	18.90	18.59	20.86
Subtotals by Category																		
1. PROJECT DEVELOPMENT	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2
2. INVESTIGATION AND DESIGN	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9
3. PROPERTY ACQUISITION	$64.7	$60.0	$62.6	$57.9	$46.2	$50.9	$48.8	$44.1	$67.8	$63.1	$65.7	$61.0	$49.4	$54.0	$51.9	$47.3	$53.9	$40.5
4. PUBLIC UTILITY ADJUSTMENTS	$13.4	$11.4	$12.9	$10.9	$10.6	$12.6	$12.1	$10.1	$8.8	$6.7	$8.3	$6.2	$5.9	$8.0	$7.5	$5.4	$5.0	$5.1
5. CONSTRUCTION	$272.1	$283.7	$275.3	$286.8	$286.6	$275.1	$278.3	$289.8	$316.1	$327.6	$319.2	$330.7	$330.6	$319.1	$322.2	$333.7	$392.3	$375.9
6. PROJECT HANDOVER	$6.1	$6.1	$6.2	$6.2	$7.0	$7.0	$7.0	$7.0	$6.2	$6.2	$6.3	$6.3	$7.1	$7.1	$7.1	$7.1	$7.3	$7.3
TOTAL PROJECT COST	$383	$388	$384	$389	$378	$373	$373	$378	$426	$431	$427	$431	$420	$415	$416	$421	$486	$456

Option Number	Option A / T2						Preferred Route									Option B / T2	Option C / T2	Option D / T2
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Option Sections	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	C/D	C/D
	A1a	B1a	A1a	B1a	B1a	A1a	A1a	B1a	A1a	B1a	A1a	B1a	B1a	A1a	A1a	B1a	C1	D1
	A1b	A1b	B1b	B1b	A1b	A1b	B1b	B1b	A1b	A1b	B1b	B1b	A1b	A1b	B1b	B1b	T2	T2
	A1c	A1c	A1c	A1c	B1c	B1c	B1c	B1c	A1c	A1c	A1c	A1c	B1c	B1c	B1c	B1c		
	A2	A2	A2	A2	A2	A2	A2	A2	B2	B2	B2	B2	B2	B2	B2	B2		
	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2		
Length of Section (km)	19.63	19.56	19.55	19.48	19.59	19.66	19.58	19.51	19.92	19.85	19.84	19.77	19.88	19.95	19.87	19.79	19.49	21.76
Subtotals by Category																		
1. PROJECT DEVELOPMENT	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2	$17.2
2. INVESTIGATION AND DESIGN	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9	$9.9
3. PROPERTY ACQUISITION	$64.6	$60.0	$62.5	$57.9	$46.2	$50.9	$48.7	$44.1	$67.7	$63.1	$65.6	$61.0	$49.3	$54.0	$51.9	$47.2	$53.8	$40.4
4. PUBLIC UTILITY ADJUSTMENTS	$13.9	$11.8	$13.4	$11.3	$11.0	$13.1	$12.6	$10.5	$9.2	$7.2	$8.7	$6.7	$6.4	$8.4	$7.9	$5.9	$5.5	$5.6
5. CONSTRUCTION	$283.4	$294.9	$286.6	$298.1	$297.9	$286.4	$289.5	$301.1	$327.4	$338.9	$330.5	$342.7	$341.9	$330.3	$333.5	$345.0	$403.6	$387.8
6. PROJECT HANDOVER	$6.3	$6.3	$6.3	$6.3	$7.1	$7.1	$7.2	$7.2	$6.4	$6.4	$6.4	$6.4	$7.2	$7.2	$7.3	$7.3	$7.5	$7.5
TOTAL PROJECT COST	$395	$400	$396	$401	$389	$385	$385	$390	$438	$443	$438	$444	$432	$427	$428	$432	$497	$468

Appendix D

Evaluation Criteria Weightings

Comparison of CAW, VMW and Project Team Evaluation Criteria Weightings

	SILO AND CRITERIA (Note 1)	Project Team Sieve 2	CAW	VMW		
				Social	Economic	VMW Average
SAFETY AND FUNCTIONALITY		**100.0%**	**100.00%**			**100.00%**
1	**Travel Efficiency**	**20.8%**	**23.75%**			**28.0%**
1.1	Travel time along Pacific Highway upgrade	10.0%	3.75%			9.0%
1.2	Local road network accessibility	10.9%	20.00%			19.0%
2	**Improve Safety**	**50.0%**	**37.50%**			**27.5%**
2.1	Accident rates	44.3%				
2.2	Length through potentially fog prone areas	5.7%				
3	**Hydrology**	**7.3%**				
3.1	Length of route within 1% AEP flood extent	7.3%				
4	**Buildability**	**21.9%**	**8.75%**			**14.0%**
4.1	Ability to stage construction	8.7%				
4.2	Disruption to traffic during construction	4.7%				
4.3	Construction risks	8.5%	8.75%			14.0%
	Aesthetics from the highway		**13.75%**			**3.0%**
	Impact on existing infrastructure and utilities		**5.00%**			**10.5%**
	Use of existing highway infrastructure		**11.25%**			**17.0%**
SOCIAL AND ECONOMIC		**100.0%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
5	**Economic impact on Agricultural Businesses**	**18.8%**	**21.30%**	**15.0%**	**33.0%**	**24.0%**
5.1	Reduction in worth of agricultural land and improvements	18.8%	21.30%	15.0%	33.0%	24.0%
6	**Impacts on Northern Rivers Regional Economy**	**3.0%**	**0.90%**	**1.0%**	**6.0%**	**3.5%**
6.1	Loss of output to regional economy from changes in agricultural land use	3.0%	0.90%	1.0%	6.0%	3.5%
7	**Impacts on Local Economy**	**9.5%**	**12.00%**	**7.0%**	**11.0%**	**9.0%**
7.1	Loss of income to local economy	9.5%	12.00%	7.0%	11.0%	9.0%
8	**Impacts on Residential Areas**	**21.7%**	**36.20%**	**21.0%**	**16.0%**	**18.5%**
8.1	Total number of dwellings within footprint that are to be acquired	6.1%	6.50%	6.0%	5.0%	5.5%
8.2	Number of dwellings to be acquired outside of 200m from existing highway	5.3%				
8.3	Value of rural residential lost	3.5%				
8.4	Number of existing contiguous settlements severed	5.7%	24.10%	14.0%	3.0%	8.5%
8.5	Area of planned future residential development land impacted	1.2%	5.60%	1.0%	8.0%	4.5%
9	**Noise**	**22.0%**	**13.00%**	**17.0%**	**4.0%**	**10.5%**
9.1	Noise - Absolute Community Noise Burden	5.8%				
9.2	Noise - Relative Community Noise Burden	6.6%				
9.3	Extent & length of steep grades (i.e. 3% or greater)	4.1%				
9.4	Number of houses that exceed the ECRTN target criteria	5.6%				
10	**Lifestyle**	**13.7%**		**17.0%**	**4.0%**	**10.5%**
10.1	10.1 Proximity to highway	13.7%		17.0%	4.0%	10.5%
11	**Visual Amenity**	**11.3%**	**9.20%**	**14.0%**	**8.0%**	**11.0%**
11.1	From point of view of resident / visitor	8.4%	9.20%	14.0%	8.0%	11.0%
11.2	From point of view of driving experience	3.0%				
	Impact of changed hydrology		**7.40%**	**8.0%**	**18.0%**	**13.0%**
NATURAL & CULTURAL ENVIRONMENT		**100.0%**	**100.00%**			**100.00%**
12	**Terrestrial Ecology**	**31.3%**	**35.40%**			**43.1%**
12.1	Impact on EECs and other high value vegetation or habitat patches directly affected	13.2%	26.10%			18.1%
12.2	Impact medium value vegetation or habitat patches directly affected	6.0%	6.20%			12.5%
12.3	Number of 'edges' created through remnant and regenerated habitat areas	5.6%				
12.4	Impact on wildlife corridors (Note 2)	6.4%	3.10%			12.5%
13	**Aquatic Ecology (Note 2)**	**17.1%**	**3.10%**			**9.7%**
13.1	Impact on waterways (high value)	11.2%				
13.2	Impact on waterways (medium value)	4.6%				
13.3	Impact on waterways (low value)	1.3%				
14	**Heritage**	**23.3%**	**36.9%**			**26.4%**
14.1	Impact on Indigenous sites	14.9%	20.0%			26.4%
14.2	Impact on non-indigenous sites	8.5%	16.9%			0.0%
15	**Air Quality**	**6.7%**				
15.1	Reduction in GHG emissions compared to 'do nothing' scenario	6.7%				
16	**Drinking Water Quality**	**8.8%**	**0.00%**			**12.5%**
16.1	Risk of disturbance to Emigrant Dam Water Catchment	6.1%				8.6%
16.2	Risks of disturbance to proposed Lismore Source Water Catchment	2.7%				3.9%
17	**Surface & Groundwater**	**12.9%**	**9.20%**			
17.1	Affect on springs	8.5%	6.1%			
17.2	Area of catchments requiring diversion	4.4%	3.1%			
	Impact on landscape		**15.40%**			**8.3%**

Note 1 This comparison uses the Project Team's Sieve 2 criteria as a baseline and shows the corresponding weightings for CAW and VMW criteria. Each group established criteria by silos (major groupings). However the VMW group had separate silos for Social and Economic; therefore, an average VMW weighting for Social and Economic is provided for comparison purposes. Additionally, some of the criteria used by the CAW and VMW groups were allocated to different silos than criteria used in the Project Team's Sieve 2. For instance, the Project Team has Hydrology and Flooding in the Safety and Functionality silo (No.3), while the CAW and VMW groups allocated 'Impact of changed hydrology' to the Social and Economic silo. The numbered criteria are the Sieve 2 criteria used by the Project Team in the technical assessment of the short list of route options. Unnumbered criteria in italics are criteria developed in the CAW or VMW that did not have corresponding criteria for the particular silo.

Note 2 CAW weighting of 6.2% for 'Impact on wildlife corridors and terrestrial and aquatic habitats' has been split into 3.1% for '12.4 Impact on wildlife corridors' and 3.1% for '13 Aquatic ecology'

Appendix E

Measures of Sieve 2 Criteria

Measures of Sieve 2 Criteria for the Short List of Route Options (Page 1)

		Option Number		Option A / T1															Option B / T1	Option C / T1	Option D / T1
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		Option Sections		A/B A1a A1b A1c A2 T1	A/B B1a A1b A1c A2 T1	A/B A1a B1b A1c A2 T1	A/B B1a B1b A1c A2 T1	A/B B1a A1b B1c A2 T1	A/B A1a A1b B1c A2 T1	A/B A1a B1b B1c A2 T1	A/B B1a B1b B1c A2 T1	A/B A1a A1b A1c B2 T1	A/B B1a A1b A1c B2 T1	A/B A1a B1b A1c B2 T1	A/B B1a B1b A1c B2 T1	A/B B1a A1b B1c B2 T1	A/B A1a A1b B1c B2 T1	A/B A1a B1b B1c B2 T1	A/B B1a B1b B1c B2 T1	C/D C1 T1	C/D D1 T1
	Sieve 2 Criteria	Sieve 2 Measurable	Measure																		
Safety and Functionality	1 Travel Efficiency	Travel Time - Light Vehicles	Minutes (1)	11.9	11.9	11.9	11.8	11.9	11.9	11.9	11.8	12.1	12.0	12.0	12.0	12.1	12.1	12.1	12.0	11.8	13.2
		Travel Time - Heavy Vehicles	Minutes (1)	13.6	13.5	13.5	13.5	13.6	13.6	13.5	13.5	13.9	13.9	13.9	13.8	13.9	13.9	13.9	13.8	14.0	14.4
		Disruption / Extra travel distances for local traffic	Qualitative score (2)	22	22	23	23	24	24	25	25	23	23	24	24	25	25	26	26	24	25
	2 Improve Safety	Number of safety concerns raised in Safety Audit	Number (1)	12	12	10	9.00	11.75	12.25	9.50	9.00	11.75	11.25	9.00	8.50	11.25	11.75	9.00	8.50	6.25	7.75
		Length through potentially fog prone areas	Metres (1)	7,895	7,895	8,003	8,003	7,322	7,322	7,429	7,429	6,455	6,455	6,562	6,562	5,882	5,882	5,989	5,989	10,966	15,489
	3 Hydrology and Flooding	Length of route within 1% AEP flood extent	Metres (1)	985	985	997	997	1,051	1,051	1,063	1,063	1,065	1,065	1,077	1,077	1,131	1,131	1,143	1,143	4,908	8,645
	4 Buildability	Ability to stage construction	Qualitative score (2)	25	25	25	25	25	25	25	25	24	24	24	24	24	24	24	24	7	7
		Disruption to traffic on existing highway during construction	Qualitative score (2)	18	20	18	20	23	21	21	23	20	22	20	22	25	23	23	25	28	28
		Length of major structures	Metres (1)	939	1059	1014	1134	1199	1079	1154	1,274	1,554	1674	1629	1749	1814	1694	1769	1889	2855	2875
		Length of route through areas of geological instability	Metres (1)	165	165	165	165	165	165	165	165	168	168	168	168	168	168	168	168	1,127	445
		Total number of known springs directly affected	Number (1)	4	3	4	3	3	4	4	3	4	3	4	3	3	4	4	3	4	3
		Number of known springs in double sided cuts directly affected	Number (1)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2	0
		Length of route through acid sulphate soils	Metres (1)	764	764	764	764	764	764	764	764	764	764	764	764	764	764	764	764	5,024	9,359
		Length of route through soft soils	Metres (1)	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976	3,473	7,587
		Preliminary imbalance in earthworks	Cubic metres (3)	316,480	122,553	-364,330	-558,257	432,170	626,097	-54,713	-248,640	227,968	34,041	-452,842	-646,769	343,658	537,585	-143,225	-337,152	-261,072	-725,844
		Number of dwellings within 100m of outer edge of footprint	Number (1)	113	98	103	88	67	82	72	57	115	100	105	90	69	84	74	59	71	48
Social and Economic	5 Economic Impact on Agricultural Business	Reduction in worth of agricultural land and improvements	Dollars (1)	$8,229,124	$8,569,290	$8,981,311	$9,321,477	$8,903,032	$8,562,866	$9,315,053	$9,655,219	$8,179,915	$8,520,081	$8,932,102	$9,272,268	$8,853,823	$8,513,657	$9,265,844	$9,606,010	$5,782,010	$5,160,794
	6 Impacts on Northern Rivers Regional Economy	Loss of output to regional economy from changes in agricultural land use	Dollars (1)	$1,287,000	$1,145,000	$1,244,000	$1,161,000	$1,331,000	$1,414,000	$1,430,000	$1,346,000	$1,205,000	$1,122,000	$1,222,000	$1,138,000	$1,307,000	$1,391,000	$1,407,000	$1,323,000	$519,000	$502,000
	7 Impacts on Local Economy	Qualitative assessment of local business impacts	Qualitative score (2)	72	72	80	80	80	80	88	88	76	76	84	84	84	84	92	92	90	100
	8 Impacts on Residential Areas	Total number of directly affected dwellings	Number (1)	31	23	32	24	16	24	25	17	32	24	33	25	17	25	26	18	22	14
		Number of directly affected dwellings that are not within 200m of existing highway	Number (1)	2	2	5	5	3	3	6	6	3	3	6	6	4	4	7	7	22	14
		Value of rural residential lost	Dollars (1)	$23,352,464	$20,457,307	$23,885,610	$20,990,453	$12,748,035	$15,643,192	$16,176,338	$13,281,181	$25,109,804	$22,214,647	$25,642,950	$22,747,793	$14,505,375	$17,400,532	$17,933,678	$15,038,521	$22,305,071	$15,743,204
		Number of existing contiguous settlements severed	Number (1)	6	5	6	5	4	5	5	4	7	6	7	6	5	6	6	5	5	3
		Area of planned future residential development land directly affected	Hectares	23.2	23.9	23.2	23.9	23.9	23.2	23.2	23.9	23.2	23.9	23.2	23.9	23.9	23.2	23.2	23.9	39.5	39.5
	9 Noise	Absolute Community Noise Burden	Quantitative score (1)	2,744	2,803	2,523	2,582	2,780	2,721	2,500	2,559	1,650	1,709	1,429	1,488	1,686	1,627	1,406	1,465	977	946
		Relative Community Noise Burden	Quantitative score (4)	-1,447	-1,524	-1,593	-1,670	-1,602	-1,525	-1,671	-1,748	-1,853	-1,930	-1,999	-2,076	-2,008	-1,931	-2,077	-2,154	-2,652	-2,665
		Length of steep grades (exceeding 3%)	Metres (1)	7,855	8,150	7,745	8,040	7,670	7,375	7,265	7,560	6,530	6,825	6,420	6,715	6,345	6,050	5,940	6,235	8,415	5,720
		Number of houses where noise levels would exceed the ECRTN target criteria	Number (1)	90	96	75	81	95	89	74	80	52	58	37	43	57	51	36	42	28	22
	10 Lifestyle	Number of dwellings within 100m of outer edge of footprint	Number (1)	113	98	103	88	67	82	72	57	115	100	105	90	69	84	74	59	71	48
	11 Landscape and Visual Amenity	From point of view resident / visitor	Qualitative score (1)	59.5	59.8	61.5	61.8	60.9	60.5	62.5	62.9	61.7	62.1	63.7	64.0	63.1	62.7	64.7	65.0	82.1	74.3
		From point of view of driving experience	Qualitative score (1)	61.0	61.4	59.2	59.6	60.4	60.0	58.2	58.6	55.2	55.6	53.4	53.8	54.6	54.2	52.4	52.8	33.4	32.9
Natural and Cultural Environment	12 Terrestrial Ecology	Number of EECs and other high value vegetation or habitat patches directly affected.	Number (1)	10	11	10	11	11	10	10	11	11	12	11	12	12	11	11	12	19	13
		Area of EECs and other high value vegetation or habitat patches directly affected.	Hectares (1)	3.0	3.2	3.3	3.5	3.2	3.0	3.3	3.5	2.3	2.5	2.6	2.8	2.5	2.3	2.6	2.8	8.2	5.2
		Number of medium value vegetation or habitat patches directly affected.	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		Area of medium value vegetation or habitat patches directly affected.	Hectares (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0
		Number of edges created through remnant or regenerated habitat areas	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		Number of regional wildlife corridor crossings	Number (1)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Number of sub-regional wildlife corridor crossings	Number (1)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3
	13 Aquatic Ecology	Number of high value waterways crossed	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Number of medium value waterways crossed	Number (1)	3	3	4	4	3	3	4	4	2	2	3	3	2	2	3	3	0	0
		Number of low value waterways crossed	Number (1)	5	5	3	3	5	5	3	3	7	7	5	5	7	7	5	5	5	3
	14 Heritage	Number of indigenous sites of national significance directly affected	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Number of indigenous sites of state or regional significance directly affected	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Number of indigenous sites of local significance directly affected	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
		Area of PADs directly affected	Hectares (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	4.5	18.6
		Number of non-indigenous sites of national significance directly affected	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Number of non-indigenous sites of state or regional significance directly affected	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Number of non-indigenous sites of local significance directly affected	Number (1)	6	7	6	7	5	4	4	5	6	7	6	7	5	4	4	5	1	0
	15 Air Quality	Savings in CO2 emissions compared to 'do-nothing' option	Tonnes per annum (2)	17,032	16,852	16,780	16,600	16,849	17,029	16,777	16,596	17,383	17,203	17,131	16,950	17,199	17,380	17,127	16,947	16,918	13,951
	16 Drinking Water Quality	Length of route option through Emigrant Dam Water Catchment	Metres (1)	4,710	4,824	4,610	4,723	5,343	5,230	5,129	5,243	4,710	4,824	4,610	4,723	5,343	5,230	5,129	5,243	1,864	0
		Length of route option within 40m of Emigrant Creek	Metres (1)	280	280	210	210	280	280	210	210	280	280	210	210	280	280	210	210	91	0
		Proximity of route option at its closest point to Emigrant Creek Dam	Metres (2)	847	665	768	665	665	847	768	665	847	665	768	665	665	847	768	665	2,105	2,105
		Length of route option through proposed Lismore Source Water Catchment	Metres (1)	7,876	7,876	7,876	7,876	7,398	7,398	7,398	7,398	8,165	8,165	8,165	8,165	7,687	7,687	7,687	7,687	6,305	5,938
	17 Surface and Ground Water	Total number of known springs directly affected	Number (1)	4	3	4	3	3	4	4	3	4	3	4	3	3	4	4	3	4	3
		Number of known springs in double sided cuts that are directly affected	Number (1)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2	0
		Area of catchments requiring diversion	Hectares (1)	22	30	27	35	21	13	19	27	28	36	33	41	28	20	25	33	23	18

Note (1) - Lower number is better and/or indicates lesser impacts

Note (2) - Higher number is better and/or indicates lesser impacts

Note (3) - Options with a larger shortage of material (ie more highly positive) are worse than those with a greater excess of material (ie more highly negative) which can potentially be made available for use on other projects

Note (4) - For the Relative Community Noise Burden a larger negative number such as say -2500 is better as it represents a greater relative reduction in noise levels than say -1500

Measures of Sieve 2 Criteria for the Short List of Route Options (Page 2)

Option Number				**Option A / T2**						***(Preferred Route)***									**Option B / T2**	**Option C / T2**	**Option D / T2**
				19	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
Option Sections				**A/B A1a A1b A1c A2 T2**	**A/B B1a A1b A1c A2 T2**	**A/B A1a B1b A1c A2 T2**	**A/B B1a B1b A1c A2 T2**	**A/B B1a A1b B1c A2 T2**	**A/B A1a A1b B1c A2 T2**	**A/B A1a B1b B1c A2 T2**	**A/B B1a B1b B1c A2 T2**	**A/B A1a A1b A1c B2 T2**	**A/B B1a A1b A1c B2 T2**	**A/B A1a B1b A1c B2 T2**	**A/B B1a B1b A1c B2 T2**	**A/B B1a B1b A1b B2 T2**	**A/B A1a A1b B1c B2 T2**	**A/B A1a B1b B1c B2 T2**	**A/B B1a B1b B2 T2**	**C/D C1 T2**	**C/D D1 T2**
Sieve 2 Criteria	**Sieve 2 Measurable**	**Measure**																			
Safety and Functionality	**1 Travel Efficiency**	Travel Time - Light Vehicles	Minutes (1)	11.9	11.9	11.9	11.8	11.9	11.9	11.9	11.8	12.1	12.0	12.0	12.0	12.1	12.1	12.1	12.0	11.8	13.2
		Travel Time - Heavy Vehicles	Minutes (1)	13.5	13.4	13.4	13.4	13.5	13.5	13.4	13.4	13.8	13.8	13.8	13.7	13.8	13.8	13.8	13.7	13.9	14.3
		Disruption / Extra travel distances for local traffic	Qualitative score (2)	22	22	23	23	24	24	25	25	23	23	24	24	25	25	26	26	24	25
	2 Improve Safety	Number of safety concerns raised in Safety Audit	Number (1)	11	10	8	7.50	10.25	10.75	8.00	7.50	10.25	9.75	7.50	7.00	9.75	10.25	7.50	7.00	4.75	6.25
		Length through potentially fog prone areas	Metres (1)	7,969	7,969	8,077	8,077	7,396	7,396	7,503	7,503	6,529	6,529	6,636	6,636	5,956	5,956	6,063	6,063	11,040	15,563
	3 Hydrology and Flooding	Length of route within 1% AEP flood extent	Metres (1)	985	985	997	997	1,051	1,051	1,063	1,063	1,065	1,065	1,077	1,077	1,131	1,131	1,143	1,143	4,908	8,645
	4 Buildability	Ability to stage construction	Qualitative score (2)	25	25	25	25	25	25	25	25	24	24	24	24	24	24	24	24	7	7
		Disruption to traffic on existing highway during construction	Qualitative score (2)	18	20	18	20	23	21	21	23	20	22	20	22	25	23	23	25	28	28
		Length of major structures	Metres (1)	939	1059	1014	1134	1199	1079	1154	1,274	1,554	1674	1629	1749	1814	1694	1769	1889	2855	2875
		Length of route through areas of geological instability	Metres (1)	149	149	149	149	149	149	149	149	152	152	152	152	152	152	152	152	1,111	428
		Total number of known springs directly affected	Number (1)	4	3	4	3	3	4	4	3	4	3	4	3	3	4	4	3	4	3
		Number of known springs in double sided cuts directly affected	Number (1)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2	0
		Length of route through acid sulphate soils	Metres (1)	764	764	764	764	764	764	764	764	764	764	764	764	764	764	764	764	5,024	9,359
		Length of route through soft soils	Metres (1)	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976	3,473	7,587
		Preliminary imbalance in earthworks	Cubic metres (3)	116,796	-77,131	-564,014	-757,941	232,486	426,413	-254,397	-448,324	28,284	-165,643	-652,526	-846,453	143,974	337,901	-342,909	-536,836	-460,756	-925,528
		Number of dwellings within 100m of outer edge of footprint	Number (1)	114	99	104	89	68	83	73	58	116	101	106	91	70	85	75	60	72	49
Social and Economic	**5 Economic Impact on Agricultural Business**	Reduction in worth of agricultural land and improvements	Dollars (1)	$8,176,744	$8,516,910	$8,928,931	$9,269,097	$8,850,652	$8,510,486	$9,262,673	$9,602,839	$8,127,535	$8,467,701	$8,879,722	$9,219,888	$8,801,443	$8,461,277	$9,213,464	$9,553,630	$5,729,630	$5,108,414
	6 Impacts on Northern Rivers Regional Economy	Loss of output to regional economy from changes in agricultural land use	Dollars (1)	$1,288,000	$1,146,000	$1,245,000	$1,162,000	$1,332,000	$1,415,000	$1,431,000	$1,347,000	$1,206,000	$1,123,000	$1,223,000	$1,139,000	$1,308,000	$1,392,000	$1,408,000	$1,324,000	$520,000	$503,000
	7 Impacts on Local Economy	Qualitative assessment of local business impacts	Qualitative score (2)	72	72	80	80	80	80	88	88	76	76	84	84	84	84	92	92	90	100
	8 Impacts on Residential Areas	Total number of directly affected dwellings	Number (1)	31	23	32	24	16	24	25	17	32	24	33	25	17	25	26	18	22	14
		Number of directly affected dwellings that are not within 200m of existing highway	Number (1)	2	2	5	5	3	3	6	6	3	3	6	6	4	4	7	7	22	14
		Value of rural residential lost	Dollars (1)	$23,352,464	$20,457,307	$23,885,610	$20,990,453	$12,748,035	$15,643,192	$16,176,338	$13,281,181	$25,109,804	$22,214,647	$25,642,950	$22,747,793	$14,505,375	$17,400,532	$17,933,678	$15,038,521	$22,305,071	$15,743,204
		Number of existing contiguous settlements severed	Number (1)	6	5	6	5	4	5	5	4	7	6	7	6	5	6	6	5	5	3
		Area of planned future residential development land directly affected	Hectares	23.2	23.9	23.2	23.9	23.9	23.2	23.2	23.9	23.2	23.9	23.2	23.9	23.9	23.2	23.2	23.9	39.5	39.5
	9 Noise	Absolute Community Noise Burden	Quantitative score (1)	2,910	2,969	2,689	2,748	2,946	2,887	2,666	2,725	1,816	1,875	1,595	1,654	1,852	1,793	1,572	1,631	1,143	1,112
		Relative Community Noise Burden	Quantitative score (4)	-1,415	-1,492	-1,561	-1,638	-1,570	-1,493	-1,639	-1,716	-1,821	-1,898	-1,967	-2,044	-1,976	-1,899	-2,045	-2,122	-2,620	-2,633
		Length of steep grades (exceeding 3%)	Metres (1)	8,215	8,510	8,105	8,400	8,030	7,735	7,625	7,920	6,890	7,185	6,780	7,075	6,705	6,410	6,300	6,595	8,775	6,080
		Number of houses where noise levels would exceed the ECRTN target criteria	Number (1)	101	107	86	92	106	100	85	91	63	69	48	54	68	62	47	53	39	33
	10 Lifestyle	Number of dwellings within 100m of outer edge of footprint	Number (1)	114	99	104	89	68	83	73	58	116	101	106	91	70	85	75	60	72	49
	11 Landscape and Visual Amenity	From point of view resident / visitor	Qualitative score (1)	61.8	62.1	63.8	64.1	63.1	62.8	64.8	65.2	64.0	64.3	65.9	66.3	65.3	65.0	66.9	67.3	84.4	76.4
		From point of view of driving experience	Qualitative score (1)	62.4	62.8	60.5	61.0	61.8	61.3	59.5	59.9	56.5	57.0	54.7	55.1	56.0	55.6	53.7	54.1	34.8	34.2
Natural and Cultural Environment	**12 Terrestrial Ecology**	Number of EECs and other high value vegetation or habitat patches directly affected.	Number (1)	10	11	10	11	11	10	10	11	11	12	11	12	12	11	11	12	19	13
		Area of EECs and other high value vegetation or habitat patches directly affected.	Hectares (1)	3.1	3.3	3.3	3.5	3.3	3.1	3.3	3.5	2.4	2.6	2.6	2.8	2.6	2.4	2.6	2.8	8.2	5.2
		Number of medium value vegetation or habitat patches directly affected.	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		Area of medium value vegetation or habitat patches directly affected.	Hectares (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0
		Number of edges created through remnant or regenerated habitat areas	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		Number of regional wildlife corridor crossings	Number (1)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Number of sub-regional wildlife corridor crossings	Number (1)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3
	13 Aquatic Ecology	Number of high value waterways crossed	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Number of medium value waterways crossed	Number (1)	3	3	4	4	3	3	4	4	2	2	3	3	2	2	3	3	0	0
		Number of low value waterways crossed	Number (1)	5	5	3	3	5	5	3	3	7	7	5	5	7	7	5	5	5	3
	14 Heritage	Number of indigenous sites of national significance directly affected	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Number of indigenous sites of state or regional significance directly affected	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Number of indigenous sites of local significance directly affected	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
		Area of PADs directly affected	Hectares (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	4.5	18.6
		Number of non-indigenous sites of national significance directly affected	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Number of non-indigenous sites of state or regional significance directly affected	Number (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Number of non-indigenous sites of local significance directly affected	Number (1)	6	7	6	7	5	4	4	5	6	7	6	7	5	4	4	5	1	0
	15 Air Quality	Savings in CO2 emissions compared to 'do-nothing' option	Tonnes per annum (2)	17,063	16,883	16,811	16,630	16,879	17,060	16,807	16,627	17,414	17,234	17,161	16,981	17,230	17,410	17,158	16,978	16,949	13,982
	16 Drinking Water Quality	Length of route option through Emigrant Dam Water Catchment	Metres (1)	4,710	4,824	4,610	4,723	5,343	5,230	5,129	5,243	4,710	4,824	4,610	4,723	5,343	5,230	5,129	5,243	1,864	0
		Length of route option within 40m of Emigrant Creek	Metres (1)	280	280	210	210	280	280	210	210	280	280	210	210	280	280	210	210	91	0
		Proximity of route option at its closest point to Emigrant Creek Dam	Metres (2)	847	665	768	665	665	847	768	665	847	665	768	665	665	847	768	665	2,105	2,105
		Length of route option through proposed Lismore Source Water Catchment	Metres (1)	7,876	7,876	7,876	7,876	7,398	7,398	7,398	7,398	8,165	8,165	8,165	8,165	7,687	7,687	7,687	7,687	6,305	5,938
	17 Surface and Ground Water	Total number of known springs directly affected	Number (1)	4	3	4	3	3	4	4	3	4	3	4	3	3	4	4	3	4	3
		Number of known springs in double sided cuts that are directly affected	Number (1)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2	0
		Area of catchments requiring diversion	Hectares (1)	22	30	27	35	21	13	19	27	28	36	33	41	28	20	25	33	23	18

Note (1) - lower number is better and/or indicates lesser impacts
Note (2) - higher number is better and/or indicates lesser impacts
Note (3) - Options with a larger shortage of material (ie more highly positive) are worse than those with a greater excess of material (ie more highly negative) which can potentially be made available for use on other projects
Note (4) - For the Relative Community Noise Burden a larger negative number such as say -2500 is better as it represents a greater relative reduction in noise levels than say -1500

Appendix F

Summary of Sieve 2 Assessment Process

Summary of Sieve 2 Assessment Process (Page 1)

Option Number		Option A / T1 1		2		3		4		5		6		7		8		9	
Option Sections		A/B A1a A1b A1c A2 T1		A/B B1a A1b A1c A2 T1		A/B A1a B1b A1c A2 T1		A/B B1a B1b A1c A2 T1		A/B B1a A1b B1c A2 T1		A/B A1a A1b B1c A2 T1		A/B A1a B1b B1c A2 T1		A/B B1a B1b B1c A2 T1		A/B A1a A1b A1c B2 T1	
Options which rank in top 2/3rds in all 3 silos	10													TOP 10		TOP 10			
Average of 3 silo rankings is in top 10	10													TOP 10		TOP 10			
	Weighting (%)	uw	w	uw	w	uw	w	uw	w	uw	w	uw	w	uw	w	uw	w	uw	w
SAFETY AND FUNCTIONALITY	100.0%	29.5	2.73	30.7	2.92	31.5	3.43	32.4	3.60	31.5	2.97	30.4	2.79	32.7	3.52	33.6	3.68	29.4	2.78
1. Travel Efficiency	20.8%	8.1	0.84	8.3	0.86	8.4	0.87	8.5	0.88	8.6	0.89	8.4	0.88	8.7	0.90	8.8	0.92	7.3	0.77
1.1 Travel time along Pacific Highway upgrade	10.0%	4.5		4.6		4.7		4.8		4.6		4.4		4.6		4.7		3.5	
1.1.1 Travel Time Light Vehicles	5.0%	4.7		4.8		4.9		5.0		4.8		4.7		4.8		4.9		4.2	
1.1.2 Travel Time Heavy Vehicles	5.0%	4.2		4.3		4.5		4.6		4.3		4.2		4.4		4.6		2.8	
1.2 Disruption / Extra travel distance for local traffic	10.9%	3.7		3.7		3.8		3.8		4.0		4.0		4.1		4.1		3.8	
2. Improve Safety	50.0%	5.2	0.68	5.4	0.80	6.6	1.33	6.9	1.45	5.7	0.81	5.4	0.69	6.8	1.34	7.1	1.46	6.0	0.83
2.1 Number of issues raised in Safety Audit	44.3%	1.0		1.3		2.5		2.7		1.3		1.0		2.5		2.7		1.3	
2.2 Length through potentially fog prone areas	5.7%	4.2		4.2		4.1		4.1		4.4		4.4		4.4		4.4		4.8	
3. Hydrology and Flooding	7.3%	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36
3.1 Length of route within 1% AEP flood extent	7.3%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
4. Buildability	21.9%	11.2	0.84	12.0	0.90	11.5	0.87	12.0	0.90	12.3	0.90	11.6	0.86	12.2	0.91	12.8	0.95	11.1	0.82
4.1 Ability to stage construction	8.7%	4.2		4.2		4.2		4.2		4.2		4.2		4.2		4.2		4.0	
4.2 Disruption to traffic on existing highway during construction	4.7%	3.0		3.3		3.0		3.3		3.8		3.5		3.5		3.8		3.3	
4.3 Construction risks	8.5%	4.0		4.5		4.3		4.5		4.3		3.9		4.6		4.8		3.8	
4.3.1 Total length of major structures (bridges or drainage with length >30m	1.2%	5.0		4.8		4.8		4.6		4.5		4.7		4.6		4.3		3.7	
4.3.2 Length of route through areas of geological instability	1.2%	4.9		4.9		4.9		4.9		4.9		4.9		4.9		4.9		4.9	
4.3.3 Affect on springs	1.2%	3.8		4.6		3.8		4.6		4.6		3.8		3.8		4.6		2.6	
4.3.3.1 Total number of known springs directly affected	0.5%	2.0		4.0		2.0		4.0		4.0		2.0		2.0		4.0		2.0	
4.3.3.2 Number of known springs in double sided cuts directly affected	0.7%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		3.0	
4.3.4 Length of route through acid sulphate soils	1.2%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
4.3.5 Length of route through soft soils	1.2%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
4.3.6 Preliminary imbalance in earthworks	1.2%	3.0		5.0		5.0		5.0		2.0		1.0		5.0		5.0		4.0	
4.3.7 Number of dwellings within 100m of outer edge of footprint	1.2%	1.2		2.1		1.8		2.6		3.9		3.0		3.6		4.5		1.1	
SOCIAL AND ECONOMIC	100.0%	34.0	2.11	37.9	2.35	35.9	2.21	39.6	2.45	45.4	2.89	41.7	2.65	43.4	2.75	47.1	2.99	40.3	2.44
5. Economic impact on Agricultural Businesses	18.8%	2.3	0.42	2.0	0.37	1.6	0.30	1.3	0.24	1.7	0.31	2.0	0.37	1.3	0.24	1.0	0.19	2.3	0.43
5.1 Reduction in worth of agricultural land and improvements	18.8%	2.3		2.0		1.6		1.3		1.7		2.0		1.3		1.0		2.3	
6. Impacts on Northern Rivers Regional Economy	3.0%	1.6	0.05	2.2	0.07	1.8	0.05	2.2	0.06	1.4	0.04	1.1	0.03	1.0	0.03	1.4	0.04	2.0	0.06
6.1 Loss of output to regional economy from changes in agricultural landuse	3.0%	1.6		2.2		1.8		2.2		1.4		1.1		1.0		1.4		2.0	
7. Impacts on Local Economy	9.5%	1.0	0.10	1.0	0.10	2.1	0.20	2.1	0.20	2.1	0.20	2.1	0.20	3.3	0.31	3.3	0.31	1.6	0.15
7.1 Qualitative assessment of local business impacts	9.5%	1.0		1.0		2.1		2.1		2.1		2.1		3.3		3.3		1.6	
8. Impacts on Residential Areas	21.7%	15.1	0.58	18.6	0.77	14.2	0.53	17.6	0.72	23.2	0.99	19.8	0.80	18.8	0.75	22.2	0.94	13.2	0.48
8.1 Total number of directly affected dwellings	6.1%	1.4		3.1		1.2		2.9		4.6		2.9		2.7		4.4		1.2	
8.2 Number of directly affected dwellings not within 200m of existing highway	5.3%	5.0		5.0		4.4		4.4		4.8		4.8		4.2		4.2		4.8	
8.3 Value of rural residential lost	3.5%	1.7		2.6		1.5		2.4		5.0		4.1		3.9		4.8		1.2	
8.4 Number of existing contiguous settlements severed	5.7%	2.0		3.0		2.0		3.0		4.0		3.0		3.0		4.0		1.0	
8.5 Area of planned future residential development land directly affected	1.2%	5.0		4.8		5.0		4.8		4.8		5.0		5.0		4.8		5.0	
9. Noise	22.0%	6.6	0.35	6.0	0.32	8.3	0.45	7.8	0.43	7.0	0.37	7.5	0.39	9.3	0.49	8.7	0.47	13.5	0.73
9.1 Noise - Absolute Community Noise Burden	5.8%	1.4		1.3		1.9		1.8		1.4		1.5		1.9		1.8		3.6	
9.2 Noise - Relative Community Noise Burden	6.6%	1.1		1.3		1.6		1.8		1.6		1.4		1.8		2.1		2.4	
9.3 Length of steep grades (exceeding 3%)	4.1%	2.2		1.8		2.3		2.0		2.4		2.8		3.0		2.6		3.9	
9.4 Number of houses where noise levels would exceed the ECRTN target criteria	5.6%	1.8		1.5		2.5		2.2		1.6		1.8		2.6		2.3		3.6	
10. Lifestyle	13.7%	1.2	0.16	2.1	0.28	1.8	0.24	2.6	0.36	3.9	0.53	3.0	0.41	3.6	0.49	4.5	0.61	1.1	0.14
10.1 Number of dwellings within 100m of outer edge of footprint	13.7%	1.2		2.1		1.8		2.6		3.9		3.0		3.6		4.5		1.1	
11. Visual Amenity	11.3%	6.2	0.45	6.1	0.45	6.2	0.43	6.1	0.43	6.1	0.44	6.2	0.44	6.1	0.43	6.0	0.42	6.7	0.45
11.1 From point of view of resident / visitor	8.4%	5.0		4.9		4.7		4.6		4.8		4.8		4.5		4.5		4.6	
11.2 From point of view of driving experience	3.0%	1.2		1.2		1.5		1.4		1.3		1.4		1.6		1.6		2.0	
NATURAL & CULTURAL ENVIRONMENT	100.0%	52.0	4.12	50.7	4.06	52.3	4.06	51.0	3.99	52.8	4.14	54.1	4.20	54.3	4.14	53.0	4.07	48.7	4.00
12. Terrestrial Ecology	31.3%	17.3	1.37	17.0	1.33	17.2	1.36	16.9	1.32	17.0	1.33	17.3	1.37	17.2	1.36	16.9	1.32	17.3	1.37
12.1 Impact on EECs and other high value vegetation or habitat patches.	13.2%	4.8		4.5		4.7		4.4		4.5		4.8		4.7		4.4		4.8	
12.1.1 Number of EECs and other high value vegetation or habitat patches directly affected.	7.0%	5.0		4.6		5.0		4.6		4.6		5.0		5.0		4.6		4.6	
12.1.2 Area of EEC and other high value vegetation directly affected	6.2%	4.5		4.4		4.4		4.2		4.4		4.5		4.4		4.2		5.0	
12.2 Impacts on medium value vegetation or habitat patches	6.0%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
12.2.1 Number of medium value vegetation or habitat patches directly affected	3.3%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
12.2.2 Area of medium value vegetation or habitat patches directly affected	2.8%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
12.3 Number of 'edges' created through remnant and regenerated habitat areas	5.6%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
12.4 Impact on wildlife corridors	6.4%	2.5		2.5		2.5		2.5		2.5		2.5		2.5		2.5		2.5	
12.4.1 Number of times regional wildlife corridors are crossed	4.0%	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
12.4.2 Number of times sub-regional wildlife corridors are crossed	2.4%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
13. Aquatic Ecology	17.1%	10.0	0.69	10.0	0.69	11.0	0.67	11.0	0.67	10.0	0.69	10.0	0.69	11.0	0.67	11.0	0.67	9.0	0.71
13.1 Impact on waterways (high value)	11.2%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
13.2 Impact on waterways (medium value)	4.6%	2.0		2.0		1.0		1.0		2.0		2.0		1.0		1.0		3.0	
13.3 Impact on waterways (low value)	1.3%	3.0		3.0		5.0		5.0		3.0		3.0		5.0		5.0		1.0	
14. Heritage	23.3%	9.6	1.13	9.5	1.12	9.6	1.13	9.5	1.12	9.6	1.14	9.7	1.14	9.7	1.14	9.6	1.14	9.5	1.12
14.1 Impact on Indigenous sites	14.9%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		4.9	
14.1.1 Number of indigenous sites of national significance	6.9%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.1.2 Number of indigenous sites of state or regional significance	3.0%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.1.3 Number of indigenous sites of local significance	1.3%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.1.4 Area (ha) of potential for archaeological deposits (PADs) directly affected	3.7%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		4.6	
14.2 Impact on non-indigenous sites	8.5%	4.6		4.5		4.6		4.5		4.6		4.7		4.7		4.6		4.6	
14.2.1 Number of non-indigenous sites of national significance	5.1%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.2.2 Number of non-indigenous sites of state or regional significance	2.3%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.2.3 Number of non-indigenous sites of local significance	1.1%	1.6		1.0		1.6		1.0		2.1		2.7		2.7		2.1		1.6	
15. Air Quality	6.7%	4.6	0.30	4.4	0.29	4.3	0.28	4.1	0.27	4.3	0.29	4.6	0.30	4.3	0.28	4.1	0.27	5.0	0.33
15.1 Reduction in GHG emissions (CO2) compared to 'do nothing' scenario	6.7%	4.6		4.4		4.3		4.1		4.3		4.6		4.3		4.1		5.0	
16. Drinking Water Quality	8.8%	3.0	0.13	2.6	0.11	3.4	0.15	3.0	0.13	3.4	0.12	3.8	0.15	4.1	0.17	3.8	0.15	2.5	0.12
16.1 Risk of disturbance to Emigrant Dam Water Catchment	6.1%	1.5		1.1		1.9		1.5		1.0		1.4		1.8		1.4		1.5	
16.1.1 Length through Emigrant Dam Water Catchment	1.7%	1.5		1.4		1.5		1.5		1.0		1.1		1.2		1.1		1.5	
16.1.2 Length of route option within 40m of Emigrant Creek	2.2%	1.0		1.0		2.0		2.0		1.0		1.0		2.0		2.0		1.0	
16.1.3 Proximity of route option at its closest point to Emigrant Creek Dam	2.2%	2.0		1.0		2.0		1.0		1.0		2.0		2.0		1.0		2.0	
16.2 Risks of disturbance to proposed Lismore Source Water Catchment	2.7%	1.5		1.5		1.5		1.5		2.4		2.4		2.4		2.4		1.0	
16.2.1 Length through proposed Lismore Source Water Catchment	2.7%	1.5		1.5		1.5		1.5		2.4		2.4		2.4		2.4		1.0	
17. Surface & Groundwater	12.9%	7.6	0.49	7.3	0.51	6.8	0.46	6.5	0.48	8.5	0.56	8.8	0.54	8.0	0.51	7.7	0.53	5.5	0.35
17.1 Effect on springs	8.5%	3.8		4.6		3.8		4.6		4.6		3.8		3.8		4.6		2.6	
17.1.1 Total number of known springs directly affected	3.4%	2.0		4.0		2.0		4.0		4.0		2.0		2.0		4.0		2.0	
17.1.2 Number of known springs in double sided cuts that are directly affected	5.1%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		3.0	
17.2 Area of catchments requiring diversion	4.4%	3.8		2.7		3.0		1.9		3.9		5.0		4.2		3.1		2.9	

Option Number	Option 10		11		12		13		14		15		Option B / T1 16		Option C / T1 17		Option D / T1 18	
Option Sections	A/B B1a A1b A1c B2 T1		A/B A1a B1b A1c B2 T1		A/B B1a B1b A1c B2 T1		A/B B1a A1b B1c B2 T1		A/B A1a A1b B1c B2 T1		A/B A1a B1b B1c B2 T1		A/B B1a B1b B1c B2 T1		C/D C1 T1		C/D D1 T1	
Options which rank in top 2/3rds in all 3 silos											TOP 10							
Average of 3 silo rankings is in top 10											TOP 10		TOP 10					
	uw	w	uw	w	uw	w	uw	w	uw	w	uw	w	uw	w	uw	w	uw	w
SAFETY AND FUNCTIONALITY	30.5	2.96	31.3	3.48	32.2	3.64	31.4	3.02	30.2	2.83	32.5	3.56	33.5	3.72	26.3	3.60	19.5	2.77
1. Travel Efficiency	7.5	0.78	7.6	0.79	7.7	0.81	7.8	0.81	7.6	0.80	7.9	0.83	8.0	0.84	7.8	0.81	5.2	0.55
1.1 Travel time along Pacific Highway upgrade	3.6		3.7		3.8		3.6		3.5		3.7		3.8		3.8		1.0	
1.1.1 Travel Time Light Vehicles	4.3		4.4		4.5		4.3		4.2		4.3		4.4		5.0		1.0	
1.1.2 Travel Time Heavy Vehicles	2.9		3.0		3.2		2.9		2.8		3.0		3.1		2.6		1.0	
1.2 Disruption / Extra travel distance for local traffic	3.8		3.9		3.9		4.2		4.2		4.3		4.3		4.0		4.2	
2. Improve Safety	6.3	0.95	7.5	1.48	7.7	1.60	6.5	0.96	6.3	0.85	7.7	1.49	8.0	1.61	7.1	2.03	4.4	1.56
2.1 Number of issues raised in Safety Audit	1.5		2.7		3.0		1.5		1.3		2.7		3.0		4.2		3.4	
2.2 Length through potentially fog prone areas	4.8		4.7		4.7		5.0		5.0		5.0		5.0		2.9		1.0	
3. Hydrology and Flooding	5.0	0.36	5.0	0.36	5.0	0.36	4.9	0.36	4.9	0.36	4.9	0.36	4.9	0.36	3.0	0.22	1.0	0.07
3.1 Length of route within 1% AEP flood extent	5.0		5.0		5.0		4.9		4.9		4.9		4.9		3.0		1.0	
4. Buildability	11.8	0.87	11.3	0.84	11.8	0.87	12.2	0.89	11.4	0.83	12.0	0.88	12.6	0.92	8.5	0.55	8.9	0.58
4.1 Ability to stage construction	4.0		4.0		4.0		4.0		4.0		4.0		4.0		1.2		1.2	
4.2 Disruption to traffic on existing highway during construction	3.7		3.3		3.7		4.2		3.8		3.8		4.2		4.7		4.7	
4.3 Construction risks	4.1		4.0		4.2		4.0		3.5		4.2		4.4		2.7		3.1	
4.3.1 Total length of major structures (bridges or drainage with length >30m	3.5		3.6		3.3		3.2		3.4		3.3		3.0		1.0		1.0	
4.3.2 Length of route through areas of geological instability	4.9		4.9		4.9		4.9		4.9		4.9		4.9		1.0		3.8	
4.3.3 Affect on springs	3.4		2.6		3.4		3.4		2.6		2.6		3.4		1.4		4.6	
4.3.3.1 Total number of known springs directly affected	4.0		2.0		4.0		4.0		2.0		2.0		4.0		2.0		4.0	
4.3.3.2 Number of known springs in double sided cuts directly affected	3.0		3.0		3.0		3.0		3.0		3.0		3.0		1.0		5.0	
4.3.4 Length of route through acid sulphate soils	5.0		5.0		5.0		5.0		5.0		5.0		5.0		3.0		1.0	
4.3.5 Length of route through soft soils	5.0		5.0		5.0		5.0		5.0		5.0		5.0		3.5		1.0	
4.3.6 Preliminary imbalance in earthworks	5.0		5.0		5.0		3.0		1.0		5.0		5.0		5.0		5.0	
4.3.7 Number of dwellings within 100m of outer edge of footprint	1.9		1.6		2.5		3.8		2.9		3.5		4.4		3.6		5.0	
SOCIAL AND ECONOMIC	44.0	2.68	42.0	2.54	45.7	2.77	51.5	3.22	47.8	2.98	49.5	3.08	53.2	3.31	49.3	3.52	65.2	4.59
5. Economic impact on Agricultural Businesses	2.0	0.37	1.6	0.31	1.3	0.25	1.7	0.32	2.0	0.38	1.3	0.25	1.0	0.20	4.4	0.83	5.0	0.93
5.1 Reduction in worth of agricultural land and improvements	2.0		1.6		1.3		1.7		2.0		1.3		1.0		4.4		5.0	
6. Impacts on Northern Rivers Regional Economy	2.3	0.07	1.9	0.06	2.3	0.07	1.5	0.05	1.2	0.03	1.1	0.03	1.5	0.04	4.9	0.15	5.0	0.15
6.1 Loss of output to regional economy from changes in agricultural landuse	2.3		1.9		2.3		1.5		1.2		1.1		1.5		4.9		5.0	
7. Impacts on Local Economy	1.6	0.15	2.7	0.26	2.7	0.26	2.7	0.26	2.7	0.26	3.9	0.37	3.9	0.37	3.6	0.34	5.0	0.48
7.1 Qualitative assessment of local business impacts	1.6		2.7		2.7		2.7		2.7		3.9		3.9		3.6		5.0	
8. Impacts on Residential Areas	16.6	0.67	12.2	0.43	15.6	0.62	21.3	0.89	17.8	0.70	16.9	0.65	20.3	0.84	10.4	0.51	17.7	0.88
8.1 Total number of directly affected dwellings	2.9		1.0		2.7		4.4		2.7		2.5		4.2		3.3		5.0	
8.2 Number of directly affected dwellings not within 200m of existing highway	4.8		4.2		4.2		4.6		4.6		4.0		4.0		1.0		2.6	
8.3 Value of rural residential lost	2.1		1.0		1.9		4.5		3.6		3.4		4.3		2.0		4.1	
8.4 Number of existing contiguous settlements severed	2.0		1.0		2.0		3.0		2.0		2.0		3.0		3.0		5.0	
8.5 Area of planned future residential development land directly affected	4.8		5.0		4.8		4.8		5.0		5.0		4.8		1.0		1.0	
9. Noise	13.0	0.71	15.3	0.83	14.8	0.81	14.0	0.75	14.5	0.77	16.3	0.88	15.7	0.85	16.1	0.94	20.0	1.10
9.1 Noise - Absolute Community Noise Burden	3.5		4.0		3.9		3.5		3.7		4.1		4.0		4.9		5.0	
9.2 Noise - Relative Community Noise Burden	2.6		2.9		3.1		2.9		2.7		3.1		3.4		5.0		5.0	
9.3 Length of steep grades (exceeding 3%)	3.6		4.1		3.7		4.2		4.6		4.7		4.3		1.5		5.0	
9.4 Number of houses where noise levels would exceed the ECRTN target criteria	3.3		4.3		4.0		3.4		3.6		4.3		4.1		4.7		5.0	
10. Lifestyle	1.9	0.27	1.6	0.23	2.5	0.35	3.8	0.52	2.9	0.39	3.5	0.48	4.4	0.60	3.6	0.50	5.0	0.68
10.1 Number of dwellings within 100m of outer edge of footprint	1.9		1.6		2.5		3.8		2.9		3.5		4.4		3.6		5.0	
11. Visual Amenity	6.6	0.44	6.6	0.43	6.5	0.42	6.5	0.43	6.6	0.44	6.6	0.42	6.4	0.41	6.3	0.26	7.6	0.37
11.1 From point of view of resident / visitor	4.6		4.3		4.3		4.4		4.5		4.2		4.1		1.4		2.6	
11.2 From point of view of driving experience	2.0		2.3		2.2		2.1		2.1		2.4		2.3		4.9		5.0	
NATURAL & CULTURAL ENVIRONMENT	47.4	3.93	49.0	3.93	47.7	3.87	49.5	4.01	50.8	4.08	51.0	4.02	49.7	3.95	44.3	3.16	57.9	4.00
12. Terrestrial Ecology	17.0	1.33	17.2	1.36	16.9	1.32	17.0	1.33	17.3	1.37	17.2	1.36	16.9	1.32	4.0	0.31	14.4	1.09
12.1 Impact on EECs and other high value vegetation or habitat patches.	4.5		4.7		4.4		4.5		4.8		4.7		4.4		1.0		3.4	
12.1.1 Number of EECs and other high value vegetation or habitat patches directly affected.	4.1		4.6		4.1		4.1		4.6		4.6		4.1		1.0		3.7	
12.1.2 Area of EEC and other high value vegetation directly affected	4.9		4.8		4.7		4.9		5.0		4.8		4.7		1.0		3.1	
12.2 Impacts on medium value vegetation or habitat patches	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		5.0	
12.2.1 Number of medium value vegetation or habitat patches directly affected	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		5.0	
12.2.2 Area of medium value vegetation or habitat patches directly affected	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		5.0	
12.3 Number of 'edges' created through remnant and regenerated habitat areas	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		5.0	
12.4 Impact on wildlife corridors	2.5		2.5		2.5		2.5		2.5		2.5		2.5		1.0		1.0	
12.4.1 Number of times regional wildlife corridors are crossed	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
12.4.2 Number of times sub-regional wildlife corridors are crossed	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		1.0	
13. Aquatic Ecology	9.0	0.71	10.0	0.69	10.0	0.69	9.0	0.71	9.0	0.71	10.0	0.69	10.0	0.69	13.0	0.83	15.0	0.85
13.1 Impact on waterways (high value)	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
13.2 Impact on waterways (medium value)	3.0		2.0		2.0		3.0		3.0		2.0		2.0		5.0		5.0	
13.3 Impact on waterways (low value)	1.0		3.0		3.0		1.0		1.0		3.0		3.0		3.0		5.0	
14. Heritage	9.4	1.11	9.5	1.12	9.4	1.11	9.5	1.12	9.6	1.13	9.6	1.13	9.5	1.12	9.3	1.07	8.7	0.97
14.1 Impact on Indigenous sites	4.9		4.9		4.9		4.9		4.9		4.9		4.9		4.4		3.7	
14.1.1 Number of indigenous sites of national significance	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.1.2 Number of indigenous sites of state or regional significance	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.1.3 Number of indigenous sites of local significance	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		1.0	
14.1.4 Area (ha) of potential for archaeological deposits (PADs) directly affected	4.6		4.6		4.6		4.6		4.6		4.6		4.6		4.0		1.0	
14.2 Impact on non-indigenous sites	4.5		4.6		4.5		4.6		4.7		4.7		4.6		4.9		5.0	
14.2.1 Number of non-indigenous sites of national significance	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.2.2 Number of non-indigenous sites of state or regional significance	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.2.3 Number of non-indigenous sites of local significance	1.0		1.6		1.0		2.1		2.7		2.7		2.1		4.4		5.0	
15. Air Quality	4.8	0.32	4.7	0.31	4.5	0.30	4.8	0.32	5.0	0.33	4.7	0.31	4.5	0.30	4.4	0.30	1.0	0.07
15.1 Reduction in GHG emissions (CO2) compared to 'do nothing' scenario	4.8		4.7		4.5		4.8		5.0		4.7		4.5		4.4		1.0	
16. Drinking Water Quality	2.1	0.09	2.9	0.14	2.5	0.12	2.9	0.11	3.2	0.13	3.6	0.16	3.3	0.13	8.5	0.37	10.0	0.44
16.1 Risk of disturbance to Emigrant Dam Water Catchment	1.1		1.9		1.5		1.0		1.4		1.8		1.4		4.1		5.0	
16.1.1 Length through Emigrant Dam Water Catchment	1.4		1.5		1.5		1.0		1.1		1.2		1.1		3.6		5.0	
16.1.2 Length of route option within 40m of Emigrant Creek	1.0		2.0		2.0		1.0		1.0		2.0		2.0		3.7		5.0	
16.1.3 Proximity of route option at its closest point to Emigrant Creek Dam	1.0		2.0		1.0		1.0		2.0		2.0		1.0		5.0		5.0	
16.2 Risks of disturbance to proposed Lismore Source Water Catchment	1.0		1.0		1.0		1.9		1.9		1.9		1.9		4.3		5.0	
16.2.1 Length through proposed Lismore Source Water Catchment	1.0		1.0		1.0		1.9		1.9		1.9		1.9		4.3		5.0	
17. Surface & Groundwater	5.2	0.37	4.7	0.32	4.4	0.33	6.4	0.42	6.7	0.40	5.9	0.37	5.6	0.39	5.0	0.28	8.9	0.58
17.1 Effect on springs	3.4		2.6		3.4		3.4		2.6		2.6		3.4		1.4		4.6	
17.1.1 Total number of known springs directly affected	4.0		2.0		4.0		4.0		2.0		2.0		4.0		2.0		4.0	
17.1.2 Number of known springs in double sided cuts that are directly affected	3.0		3.0		3.0		3.0		3.0		3.0		3.0		1.0		5.0	
17.2 Area of catchments requiring diversion	1.8		2.1		1.0		3.0		4.1		3.3		2.2		3.6		4.3	

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Safety & Functionality																		
Sum of Weighted Scores	2.73	2.92	3.43	3.60	2.97	2.79	3.52	3.68	2.78	2.96	3.48	3.64	3.02	2.83	3.56	3.72	3.60	2.77
Ranking of Weighted Scores	36	31	18	13	29	33	16	11	34	30	17	12	28	32	15	10	14	35
Social and Economic																		
Sum of Weighted Scores	2.11	2.35	2.21	2.45	2.89	2.65	2.75	2.99	2.44	2.68	2.54	2.77	3.22	2.98	3.08	3.31	3.52	4.59
Ranking of Weighted Scores	34	29	33	26	13	21	18	10	27	19	25	17	6	11	9	5	3	1
Natural and Cultural Environment																		
Sum of Weighted Scores	4.12	4.06	4.06	3.99	4.14	4.20	4.14	4.07	4.00	3.93	3.93	3.87	4.01	4.08	4.02	3.95	3.16	4.00
Ranking of Weighted Scores	8	16	14	26	6	2	4	12	24	32	30	34	20	10	18	28	36	22
Average of Rankings for three silos	26.0	25.3	21.7	21.7	16.0	18.7	12.7	11.0	28.3	27.0	24.0	21.0	18.0	17.7	14.0	14.3	17.7	19.3
Rank of Average Ranking	33	32	25	25	13	19	6	3	36	35	30	24	18	16	8	9	16	22

Option ranks in top 2/3rds in that silo

Summary of Sieve 2 Assessment Process (Page 2)

Option Number		Option A / T2 19		20		21		22		23		24		Preferred Route 25		26		27	
Option Sections		A/B A1a A1b A1c A2 T2		A/B B1a A1b A1c A2 T2		A/B A1a B1b A1c A2 T2		A/B B1a B1b A1c A2 T2		A/B B1a A1b B1c A2 T2		A/B A1a A1b B1c A2 T2		A/B A1a B1b B1c A2 T2		A/B B1a B1b B1c A2 T2		A/B A1a A1b A1c B2 T2	
Options which rank in top 2/3rds in all 3 silos	10									TOP 10		TOP 10		TOP 10		TOP 10			
Average of 3 silo rankings is in top 10	10									TOP 10				TOP 10		TOP 10			
	Weighting (%)	UW	W	UW	W	UW	W	UW	W	UW	W	UW	W	UW	W	UW	W	UW	W
SAFETY AND FUNCTIONALITY	100.0%	30.7	3.13	31.7	3.29	32.5	3.81	33.4	3.97	32.7	3.37	31.5	3.18	33.7	3.89	34.6	4.06	30.5	3.17
1. Travel Efficiency	20.8%	8.4	0.87	8.5	0.88	8.6	0.89	8.8	0.91	8.8	0.91	8.6	0.90	8.9	0.93	9.0	0.94	7.6	0.79
1.1 Travel time along Pacific Highway upgrade	10.0%	4.7		4.8		4.9		5.0		4.8		4.6		4.8		5.0		3.7	
1.1.1 Travel Time Light Vehicles	5.0%	4.7		4.9		4.9		5.0		4.8		4.7		4.8		4.9		4.2	
1.1.2 Travel Time Heavy Vehicles	5.0%	4.6		4.8		4.9		5.0		4.7		4.6		4.9		5.0		3.2	
1.2 Disruption / Extra travel distance for local traffic	10.9%	3.7		3.7		3.8		3.8		4.0		4.0		4.1		4.1		3.8	
2. Improve Safety	50.0%	5.9	1.03	6.2	1.15	7.4	1.68	7.6	1.80	6.4	1.17	6.2	1.05	7.6	1.69	7.9	1.81	6.8	1.19
2.1 Number of issues raised in Safety Audit	44.3%	1.800		2.1		3.3		3.5		2.1		1.8		3.3		3.5		2.1	
2.2 Length through potentially fog prone areas	5.7%	4.1		4.1		4.1		4.1		4.4		4.4		4.3		4.3		4.7	
3. Hydrology and Flooding	7.3%	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36	5.0	0.36
3.1 Length of route within 1% AEP flood extent	7.3%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
4. Buildability	21.9%	11.4	0.87	12.0	0.90	11.5	0.87	12.0	0.90	12.6	0.93	11.7	0.87	12.2	0.91	12.8	0.95	11.2	0.84
4.1 Ability to stage construction	8.7%	4.2		4.2		4.2		4.2		4.2		4.2		4.2		4.2		4.0	
4.2 Disruption to traffic on existing highway during construction	4.7%	3.0		3.3		3.0		3.3		3.8		3.5		3.5		3.8		3.3	
4.3 Construction risks	8.5%	4.3		4.5		4.3		4.5		4.6		4.1		4.6		4.8		3.9	
4.3.1 Total length of major structures (bridges or drainage with length >30m	1.2%	5.0		4.8		4.8		4.6		4.5		4.7		4.6		4.3		3.7	
4.3.2 Length of route through areas of geological instability	1.2%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
4.3.3 Affect on springs	1.2%	3.8		4.6		3.8		4.6		4.6		3.8		3.8		4.6		2.6	
4.3.3.1 Total number of known springs directly affected	0.5%	2.0		4.0		2.0		4.0		4.0		2.0		2.0		4.0		2.0	
4.3.3.2 Number of known springs in double sided cuts directly affected	0.7%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		3.0	
4.3.4 Length of route through acid sulphate soils	1.2%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
4.3.5 Length of route through soft soils	1.2%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
4.3.6 Preliminary imbalance in earthworks	1.2%	5.0		5.0		5.0		5.0		4.0		2.0		5.0		5.0		5.0	
4.3.7 Number of dwellings within 100m of outer edge of footprint	1.2%	1.1		2.0		1.7		2.6		3.8		2.9		3.5		4.4		1.0	
SOCIAL AND ECONOMIC	100.0%	32.0	2.00	36.0	2.24	33.9	2.10	37.7	2.34	43.4	2.78	39.7	2.55	41.4	2.64	45.1	2.88	38.3	2.33
5. Economic impact on Agricultural Businesses	18.8%	2.3	0.43	2.0	0.38	1.6	0.31	1.3	0.25	1.7	0.32	2.0	0.38	1.3	0.25	1.0	0.20	2.3	0.44
5.1 Reduction in worth of agricultural land and improvements	18.8%	2.3		2.0		1.6		1.3		1.7		2.0		1.3		1.0		2.3	
6. Impacts on Northern Rivers Regional Economy	3.0%	1.6	0.05	2.2	0.07	1.8	0.05	2.2	0.06	1.4	0.04	1.1	0.03	1.0	0.03	1.4	0.04	2.0	0.06
6.1 Loss of output to regional economy from changes in agricultural landuse	3.0%	1.6		2.2		1.8		2.2		1.4		1.1		1.0		1.4		2.0	
7. Impacts on Local Economy	9.5%	1.0	0.10	1.0	0.10	2.1	0.20	2.1	0.20	2.1	0.20	2.1	0.20	3.3	0.31	3.3	0.31	1.6	0.15
7.1 Qualitative assessment of local business impacts	9.5%	1.0		1.0		2.1		2.1		2.1		2.1		3.3		3.3		1.6	
8. Impacts on Residential Areas	21.7%	15.1	0.58	18.6	0.77	14.2	0.53	17.6	0.72	23.2	0.99	19.8	0.80	18.8	0.75	22.2	0.94	13.2	0.48
8.1 Total number of directly affected dwellings	6.1%	1.4		3.1		1.2		2.9		4.6		2.9		2.7		4.4		1.2	
8.2 Number of directly affected dwellings not within 200m of existing highway	5.3%	5.0		5.0		4.4		4.4		4.8		4.8		4.2		4.2		4.8	
8.3 Value of rural residential lost	3.5%	1.7		2.6		1.5		2.4		5.0		4.1		3.9		4.8		1.2	
8.4 Number of existing contiguous settlements severed	5.7%	2.0		3.0		2.0		3.0		4.0		3.0		3.0		4.0		1.0	
8.5 Area of planned future residential development land directly affected	1.2%	5.0		4.8		5.0		4.8		4.8		5.0		5.0		4.8		5.0	
9. Noise	22.0%	5.1	0.27	4.6	0.25	6.9	0.37	6.3	0.35	5.6	0.30	6.1	0.32	7.9	0.42	7.3	0.40	12.1	0.65
9.1 Noise - Absolute Community Noise Burden	5.8%	1.1		1.0		1.6		1.4		1.0		1.2		1.6		1.5		3.3	
9.2 Noise - Relative Community Noise Burden	6.6%	1.0		1.2		1.5		1.7		1.5		1.2		1.7		2.0		2.3	
9.3 Length of steep grades (exceeding 3%)	4.1%	1.7		1.3		1.9		1.5		2.0		2.4		2.5		2.1		3.5	
9.4 Number of houses where noise levels would exceed the ECRTN target criteria	5.6%	1.3		1.0		2.0		1.7		1.0		1.3		2.0		1.8		3.1	
10. Lifestyle	13.7%	1.1	0.15	2.0	0.27	1.7	0.23	2.6	0.35	3.8	0.52	2.9	0.40	3.5	0.48	4.4	0.60	1.0	0.14
10.1 Number of dwellings within 100m of outer edge of footprint	13.7%	1.1		2.0		1.7		2.6		3.8		2.9		3.5		4.4		1.0	
11. Visual Amenity	11.3%	5.7	0.42	5.6	0.41	5.6	0.40	5.5	0.39	5.6	0.40	5.7	0.41	5.6	0.39	5.5	0.38	6.1	0.41
11.1 From point of view of resident / visitor	8.4%	4.6		4.6		4.3		4.3		4.4		4.5		4.1		4.1		4.3	
11.2 From point of view of driving experience	3.0%	1.1		1.0		1.3		1.2		1.1		1.2		1.4		1.4		1.8	
NATURAL & CULTURAL ENVIRONMENT	100.0%	52.1	4.12	50.8	4.06	52.3	4.06	51.0	3.99	52.8	4.14	54.1	4.20	54.4	4.14	53.1	4.08	48.8	4.00
12. Terrestrial Ecology	31.3%	17.3	1.37	17.0	1.33	17.2	1.36	16.9	1.32	17.0	1.33	17.3	1.37	17.2	1.36	16.9	1.32	17.3	1.37
12.1 Impact on EECs and other high value vegetation or habitat patches.	13.2%	4.8		4.5		4.7		4.4		4.5		4.8		4.7		4.4		4.8	
12.1.1 Number of EECs and other high value vegetation or habitat patches directly affected.	7.0%	5.0		4.6		5.0		4.6		4.6		5.0		5.0		4.6		4.6	
12.1.2 Area of EEC and other high value vegetation directly affected	6.2%	4.5		4.4		4.3		4.2		4.4		4.5		4.3		4.2		5.0	
12.2 Impacts on medium value vegetation or habitat patches	6.0%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
12.2.1 Number of medium value vegetation or habitat patches directly affected	3.3%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
12.2.2 Area of medium value vegetation or habitat patches directly affected	2.8%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
12.3 Number of 'edges' created through remnant and regenerated habitat areas	5.6%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
12.4 Impact on wildlife corridors	6.4%	2.5		2.5		2.5		2.5		2.5		2.5		2.5		2.5		2.5	
12.4.1 Number of times regional wildlife corridors are crossed	4.0%	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
12.4.2 Number of times sub-regional wildlife corridors are crossed	2.4%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
13. Aquatic Ecology	17.1%	10.0	0.69	10.0	0.69	11.0	0.67	11.0	0.67	10.0	0.69	10.0	0.69	11.0	0.67	11.0	0.67	9.0	0.71
13.1 Impact on waterways (high value)	11.2%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
13.2 Impact on waterways (medium value)	4.6%	2.0		2.0		1.0		1.0		2.0		2.0		1.0		1.0		3.0	
13.3 Impact on waterways (low value)	1.3%	3.0		3.0		5.0		5.0		3.0		3.0		5.0		5.0		1.0	
14. Heritage	23.3%	9.6	1.13	9.5	1.12	9.6	1.13	9.5	1.12	9.6	1.14	9.7	1.14	9.7	1.14	9.6	1.14	9.5	1.12
14.1 Impact on Indigenous sites	14.9%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		4.9	
14.1.1 Number of indigenous sites of national significance	6.9%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.1.2 Number of indigenous sites of state or regional significance	3.0%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.1.3 Number of indigenous sites of local significance	1.3%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.1.4 Area (ha) of potential for archaeological deposits (PADs) directly affected	3.7%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		4.6	
14.2 Impact on non-indigenous sites	8.5%	4.6		4.5		4.6		4.5		4.6		4.7		4.7		4.6		4.6	
14.2.1 Number of non-indigenous sites of national significance	5.1%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.2.2 Number of non-indigenous sites of state or regional significance	2.3%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.2.3 Number of non-indigenous sites of local significance	1.1%	1.6		1.0		1.6		1.0		2.1		2.7		2.7		2.1		1.6	
15. Air Quality	6.7%	4.6	0.31	4.4	0.29	4.3	0.29	4.1	0.27	4.4	0.29	4.6	0.31	4.3	0.29	4.1	0.27	5.0	0.33
15.1 Reduction in GHG emissions (CO2) compared to 'do nothing' scenario	6.7%	4.6		4.4		4.3		4.1		4.4		4.6		4.3		4.1		5.0	
16. Drinking Water Quality	8.8%	3.0	0.13	2.6	0.11	3.4	0.15	3.0	0.13	3.4	0.12	3.8	0.15	4.1	0.17	3.8	0.15	2.5	0.12
16.1 Risk of disturbance to Emigrant Dam Water Catchment	6.1%	1.5		1.1		1.9		1.5		1.0		1.4		1.8		1.4		1.5	
16.1.1 Length through Emigrant Dam Water Catchment	1.7%	1.5		1.4		1.5		1.5		1.0		1.1		1.2		1.1		1.5	
16.1.2 Length of route option within 40m of Emigrant Creek	2.2%	1.0		1.0		2.0		2.0		1.0		1.0		2.0		2.0		1.0	
16.1.3 Proximity of route option at its closest point to Emigrant Creek Dam	2.2%	2.0		1.0		2.0		1.0		1.0		2.0		2.0		1.0		2.0	
16.2 Risks of disturbance to proposed Lismore Source Water Catchment	2.7%	1.5		1.5		1.5		1.5		2.4		2.4		2.4		2.4		1.0	
16.2.1 Length through proposed Lismore Source Water Catchment	2.7%	1.5		1.5		1.5		1.5		2.4		2.4		2.4		2.4		1.0	
17. Surface & Groundwater	12.9%	7.6	0.49	7.3	0.51	6.8	0.46	6.5	0.48	8.5	0.56	8.8	0.54	8.0	0.51	7.7	0.53	5.5	0.35
17.1 Effect on springs	8.5%	3.8		4.6		3.8		4.6		4.6		3.8		3.8		4.6		2.6	
17.1.1 Total number of known springs directly affected	3.4%	2.0		4.0		2.0		4.0		4.0		2.0		2.0		4.0		2.0	
17.1.2 Number of known springs in double sided cuts that are directly affected	5.1%	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		3.0	
17.2 Area of catchments requiring diversion	4.4%	3.8		2.7		3.0		1.9		3.9		5.0		4.2		3.1		2.9	

Option Number	28		29		30		31		32		33		Option B / T2 34		Option C / T2 35		Option D / T2 36	
Option Sections	A/B B1a A1b A1c B2 T2		A/B A1a B1b A1c B2 T2		A/B B1a B1b A1c B2 T2		A/B B1a A1b B1c B2 T2		A/B A1a A1b B1c B2 T2		A/B A1a B1b B1c B2 T2		A/B B1a B1b B1c B2 T2		C/D C1 T2		C/D D1 T2	
Options which rank in top 2/3rds in all 3 silos							TOP 10		TOP 10		TOP 10							
Average of 3 silo rankings is in top 10											TOP 10		TOP 10		TOP 10			
	UW	W	UW	W	UW	W	UW	W	UW	W	UW	W	UW	W	UW	W	UW	W
SAFETY AND FUNCTIONALITY	31.5	3.33	32.3	3.85	33.2	4.01	32.5	3.41	31.5	3.23	33.5	3.93	34.4	4.10	27.3	3.97	20.5	3.14
1. Travel Efficiency	7.7	0.80	7.8	0.82	7.9	0.83	8.0	0.83	7.8	0.82	8.1	0.85	8.2	0.86	8.0	0.83	5.4	0.57
1.1 Travel time along Pacific Highway upgrade	3.8		3.9		4.0		3.8		3.7		3.9		4.0		4.0		1.2	
1.1.1 Travel Time Light Vehicles	4.4		4.4		4.5		4.3		4.2		4.3		4.4		5.0		1.0	
1.1.2 Travel Time Heavy Vehicles	3.3		3.5		3.6		3.3		3.2		3.4		3.5		3.0		1.4	
1.2 Disruption / Extra travel distance for local traffic	3.8		3.9		3.9		4.2		4.2		4.3		4.3		4.0		4.2	
2. Improve Safety	7.1	1.30	8.2	1.83	8.5	1.95	7.3	1.32	7.0	1.20	8.5	1.85	8.7	1.96	7.9	2.38	5.2	1.92
2.1 Number of issues raised in Safety Audit	2.3		3.5		3.8		2.3		2.1		3.5		3.8		5.0		4.2	
2.2 Length through potentially fog prone areas	4.7		4.7		4.7		5.0		5.0		4.9		4.9		2.9		1.0	
3. Hydrology and Flooding	5.0	0.36	5.0	0.36	5.0	0.36	4.9	0.36	4.9	0.36	4.9	0.36	4.9	0.36	3.0	0.22	1.0	0.07
3.1 Length of route within 1% AEP flood extent	5.0		5.0		5.0		4.9		4.9		4.9		4.9		3.0		1.0	
4. Buildability	11.8	0.87	11.3	0.84	11.8	0.87	12.4	0.90	11.7	0.85	12.0	0.88	12.6	0.92	8.5	0.55	8.9	0.58
4.1 Ability to stage construction	4.0		4.0		4.0		4.0		4.0		4.0		4.0		1.2		1.2	
4.2 Disruption to traffic on existing highway during construction	3.7		3.3		3.7		4.2		3.8		3.8		4.2		4.7		4.7	
4.3 Construction risks	4.1		4.0		4.2		4.2		3.8		4.2		4.4		2.7		3.1	
4.3.1 Total length of major structures (bridges or drainage with length >30m	3.5		3.6		3.3		3.2		3.4		3.3		3.0		1.0		1.0	
4.3.2 Length of route through areas of geological instability	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.1		3.9	
4.3.3 Affect on springs	3.4		2.6		3.4		3.4		2.6		2.6		3.4		1.4		4.6	
4.3.3.1 Total number of known springs directly affected	4.0		2.0		4.0		4.0		2.0		2.0		4.0		2.0		4.0	
4.3.3.2 Number of known springs in double sided cuts directly affected	3.0		3.0		3.0		3.0		3.0		3.0		3.0		1.0		5.0	
4.3.4 Length of route through acid sulphate soils	5.0		5.0		5.0		5.0		5.0		5.0		5.0		3.0		1.0	
4.3.5 Length of route through soft soils	5.0		5.0		5.0		5.0		5.0		5.0		5.0		3.5		1.0	
4.3.6 Preliminary imbalance in earthworks	5.0		5.0		5.0		4.0		3.0		5.0		5.0		5.0		5.0	
4.3.7 Number of dwellings within 100m of outer edge of footprint	1.9		1.6		2.5		3.7		2.8		3.4		4.3		3.6		4.9	
SOCIAL AND ECONOMIC	42.0	2.57	40.0	2.43	43.7	2.67	49.5	3.11	45.8	2.87	47.5	2.97	51.2	3.20	47.3	3.41	63.3	4.48
5. Economic impact on Agricultural Businesses	2.0	0.38	1.7	0.32	1.4	0.26	1.8	0.33	2.1	0.38	1.4	0.26	1.1	0.20	4.5	0.84	5.0	0.94
5.1 Reduction in worth of agricultural land and improvements	2.0		1.7		1.4		1.8		2.1		1.4		1.1		4.5		5.0	
6. Impacts on Northern Rivers Regional Economy	2.3	0.07	1.9	0.06	2.3	0.07	1.5	0.05	1.2	0.03	1.1	0.03	1.5	0.04	4.9	0.15	5.0	0.15
6.1 Loss of output to regional economy from changes in agricultural landuse	2.3		1.9		2.3		1.5		1.2		1.1		1.5		4.9		5.0	
7. Impacts on Local Economy	1.6	0.15	2.7	0.26	2.7	0.26	2.7	0.26	2.7	0.26	3.9	0.37	3.9	0.37	3.6	0.34	5.0	0.48
7.1 Qualitative assessment of local business impacts	1.6		2.7		2.7		2.7		2.7		3.9		3.9		3.6		5.0	
8. Impacts on Residential Areas	16.6	0.67	12.2	0.43	15.6	0.62	21.3	0.89	17.8	0.70	16.9	0.65	20.3	0.84	10.4	0.51	17.7	0.88
8.1 Total number of directly affected dwellings	2.9		1.0		2.7		4.4		2.7		2.5		4.2		3.3		5.0	
8.2 Number of directly affected dwellings not within 200m of existing highway	4.8		4.2		4.2		4.6		4.6		4.0		4.0		1.0		2.6	
8.3 Value of rural residential lost	2.1		1.0		1.9		4.5		3.6		3.4		4.3		2.0		4.1	
8.4 Number of existing contiguous settlements severed	2.0		1.0		2.0		3.0		2.0		2.0		3.0		3.0		5.0	
8.5 Area of planned future residential development land directly affected	4.8		5.0		4.8		4.8		5.0		5.0		4.8		1.0		1.0	
9. Noise	11.6	0.63	13.9	0.76	13.3	0.73	12.5	0.68	13.1	0.70	14.8	0.80	14.3	0.78	14.7	0.86	18.6	1.03
9.1 Noise - Absolute Community Noise Burden	3.2		3.7		3.6		3.2		3.3		3.8		3.6		4.6		4.7	
9.2 Noise - Relative Community Noise Burden	2.5		2.8		3.0		2.8		2.5		3.0		3.3		4.9		4.9	
9.3 Length of steep grades (exceeding 3%)	3.1		3.6		3.2		3.7		4.1		4.2		3.9		1.0		4.5	
9.4 Number of houses where noise levels would exceed the ECRTN target criteria	2.8		3.8		3.5		2.8		3.1		3.8		3.5		4.2		4.5	
10. Lifestyle	1.9	0.26	1.6	0.22	2.5	0.34	3.7	0.51	2.8	0.39	3.4	0.47	4.3	0.59	3.6	0.49	4.9	0.68
10.1 Number of dwellings within 100m of outer edge of footprint	1.9		1.6		2.5		3.7		2.8		3.4		4.3		3.6		4.9	
11. Visual Amenity	6.0	0.41	6.0	0.39	5.9	0.39	6.0	0.40	6.1	0.40	6.0	0.38	5.9	0.38	5.8	0.22	7.1	0.33
11.1 From point of view of resident / visitor	4.2		4.0		3.9		4.1		4.1		3.8		3.7		1.0		2.3	
11.2 From point of view of driving experience	1.8		2.1		2.0		1.9		2.0		2.2		2.2		4.8		4.8	
NATURAL & CULTURAL ENVIRONMENT	47.5	3.93	49.0	3.94	47.7	3.87	49.5	4.01	50.8	4.08	51.1	4.02	49.8	3.95	44.3	3.16	58.0	4.00
12. Terrestrial Ecology	17.0	1.33	17.2	1.36	16.9	1.32	17.0	1.33	17.3	1.37	17.2	1.36	16.9	1.32	4.0	0.31	14.4	1.09
12.1 Impact on EECs and other high value vegetation or habitat patches.	4.5		4.7		4.4		4.5		4.8		4.7		4.4		1.0		3.4	
12.1.1 Number of EECs and other high value vegetation or habitat patches directly affected.	4.1		4.6		4.1		4.1		4.6		4.6		4.1		1.0		3.7	
12.1.2 Area of EEC and other high value vegetation directly affected	4.8		4.8		4.7		4.8		5.0		4.8		4.7		1.0		3.0	
12.2 Impacts on medium value vegetation or habitat patches	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		5.0	
12.2.1 Number of medium value vegetation or habitat patches directly affected	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		5.0	
12.2.2 Area of medium value vegetation or habitat patches directly affected	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		5.0	
12.3 Number of 'edges' created through remnant and regenerated habitat areas	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		5.0	
12.4 Impact on wildlife corridors	2.5		2.5		2.5		2.5		2.5		2.5		2.5		1.0		1.0	
12.4.1 Number of times regional wildlife corridors are crossed	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
12.4.2 Number of times sub-regional wildlife corridors are crossed	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		1.0	
13. Aquatic Ecology	9.0	0.71	10.0	0.69	10.0	0.69	9.0	0.71	9.0	0.71	10.0	0.69	10.0	0.69	13.0	0.83	15.0	0.85
13.1 Impact on waterways (high value)	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
13.2 Impact on waterways (medium value)	3.0		2.0		2.0		3.0		3.0		2.0		2.0		5.0		5.0	
13.3 Impact on waterways (low value)	1.0		3.0		3.0		1.0		1.0		3.0		3.0		3.0		5.0	
14. Heritage	9.4	1.11	9.5	1.12	9.4	1.11	9.5	1.12	9.6	1.13	9.6	1.13	9.5	1.12	9.3	1.07	8.7	0.97
14.1 Impact on Indigenous sites	4.9		4.9		4.9		4.9		4.9		4.9		4.9		4.4		3.7	
14.1.1 Number of indigenous sites of national significance	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.1.2 Number of indigenous sites of state or regional significance	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.1.3 Number of indigenous sites of local significance	5.0		5.0		5.0		5.0		5.0		5.0		5.0		1.0		1.0	
14.1.4 Area (ha) of potential for archaeological deposits (PADs) directly affected	4.6		4.6		4.6		4.6		4.6		4.6		4.6		4.0		1.0	
14.2 Impact on non-indigenous sites	4.5		4.6		4.5		4.6		4.7		4.7		4.6		4.9		5.0	
14.2.1 Number of non-indigenous sites of national significance	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.2.2 Number of non-indigenous sites of state or regional significance	5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0		5.0	
14.2.3 Number of non-indigenous sites of local significance	1.0		1.6		1.0		2.1		2.7		2.7		2.1		4.4		5.0	
15. Air Quality	4.8	0.32	4.7	0.31	4.5	0.30	4.8	0.32	5.0	0.33	4.7	0.31	4.5	0.30	4.5	0.30	1.0	0.07
15.1 Reduction in GHG emissions (CO2) compared to 'do nothing' scenario	4.8		4.7		4.5		4.8		5.0		4.7		4.5		4.5		1.0	
16. Drinking Water Quality	2.1	0.09	2.9	0.14	2.5	0.12	2.9	0.11	3.2	0.13	3.6	0.16	3.3	0.13	8.5	0.37	10.0	0.44
16.1 Risk of disturbance to Emigrant Dam Water Catchment	1.1		1.9		1.5		1.0		1.4		1.8		1.4		4.1		5.0	
16.1.1 Length through Emigrant Dam Water Catchment	1.4		1.5		1.5		1.0		1.1		1.2		1.1		3.6		5.0	
16.1.2 Length of route option within 40m of Emigrant Creek	1.0		2.0		2.0		1.0		1.0		2.0		2.0		3.7		5.0	
16.1.3 Proximity of route option at its closest point to Emigrant Creek Dam	1.0		2.0		1.0		1.0		2.0		2.0		1.0		5.0		5.0	
16.2 Risks of disturbance to proposed Lismore Source Water Catchment	1.0		1.0		1.0		1.9		1.9		1.9		1.9		4.3		5.0	
16.2.1 Length through proposed Lismore Source Water Catchment	1.0		1.0		1.0		1.9		1.9		1.9		1.9		4.3		5.0	
17. Surface & Groundwater	5.2	0.37	4.7	0.32	4.4	0.33	6.4	0.42	6.7	0.40	5.9	0.37	5.6	0.39	5.0	0.28	8.9	0.58
17.1 Effect on springs	3.4		2.6		3.4		3.4		2.6		2.6		3.4		1.4		4.6	
17.1.1 Total number of known springs directly affected	4.0		2.0		4.0		4.0		2.0		2.0		4.0		2.0		4.0	
17.1.2 Number of known springs in double sided cuts that are directly affected	3.0		3.0		3.0		3.0		3.0		3.0		3.0		1.0		5.0	
17.2 Area of catchments requiring diversion	1.8		2.1		1.0		3.0		4.1		3.3		2.2		3.6		4.3	

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Safety & Functionality																		
Sum of Weighted Scores	3.13	3.29	3.81	3.97	3.37	3.18	3.89	4.06	3.17	3.33	3.85	4.01	3.41	3.23	3.93	4.10	3.97	3.14
Ranking of Weighted Scores	27	22	9	4	20	24	7	2	25	21	8	3	19	23	6	1	5	26
Social and Economic																		
Sum of Weighted Scores	2.00	2.24	2.10	2.34	2.78	2.55	2.64	2.88	2.33	2.57	2.43	2.67	3.11	2.87	2.97	3.20	3.41	4.48
Ranking of Weighted Scores	36	32	35	30	16	24	22	14	31	23	28	20	8	15	12	7	4	2
Natural and Cultural Environment																		
Sum of Weighted Scores	4.12	4.06	4.06	3.99	4.14	4.20	4.14	4.08	4.00	3.93	3.94	3.87	4.01	4.08	4.02	3.95	3.16	4.00
Ranking of Weighted Scores	7	15	13	25	5	1	3	11	23	31	29	33	19	9	17	27	35	21
Average of Rankings for three silos	23.3	23.0	19.0	19.7	13.7	16.3	10.7	9.0	26.3	25.0	21.7	18.7	15.3	15.7	11.7	11.7	14.7	16.3
Rank of Average Ranking	29	28	21	23	7	14	2	1	34	31	25	19	11	12	4	4	10	14

Option ranks in top 2/3rds in that silo